TRANSACTIONS AND PROCEEDINGS

OF THE

ROYAL SOCIETY OF SOUTH AUSTRALIA

(INCORPORATED).

VOL. LIII.

[WITH ELEVEN PLATES, AND SEVENTY-EIGHT FIGURES IN THE TEXT.]

EDITED BY PROFESSOR WALTER HOWCHIN, F.G.S.
ASSISTED BY ARTHUR M. LEA, F.E.S.

[*Each Author is responsible for the soundness of the opinions given, and for the accuracy of the statements made in his paper.*]

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of

The Royal Society of South Australia (Incorporated)

VOL. LIII.

FURTHER NOTES ON THE NEWLY-DISCOVERED FOSSILS IN THE ADELAIDE SERIES (LIPALIAN OR PROTEROZOIC), SOUTH AUSTRALIA.

By PROFESSOR T. W. EDGEWORTH DAVID, K.B.E., C.M.G., F.R.S., etc.

[Read April 11, 1929.]

PLATE I.

In view of the fact that so much time was needed in order to develop out the remains of the Eurypterids [1] from the hard siliceous limestones and quartzites of the Lipalian (or Pre-Cambrian) rocks of the Adelaide Series that the printing of the plates had to be proceeded with before some of the fossils had been fully traced out, the author is adding this note and Plate I., together with a brief description.

The author estimates that in a thickness of five feet of the Blue Metal Limestone of the Adelaide Series, fragments of Arachnids (mostly small pieces) are present at the rate of over 100 per square foot. Some of these Arachnids in the Adelaide Series may have been over a foot in length. It is quite possible, in his opinion, that in Lipalian time (Infra-Cambrian-pre-trilobite time—or late Proterozoic time) the seas probably of the whole world were dominated by the important group of the Arachnids, from which, in the opinion of some eminent zoologists, vertebrate life was eventually evolved. The climatological significance of this great Arachnid belt cannot be too strongly emphasised. At present the existing Merostomes range from the tropics to warm temperate latitudes. Professor Harvey Johnston and Miss Deland inform me that in the Pacific, the Limuloids, or King Crabs, are met with from the Moluccas up to China and Southern Japan, as well as India; and that in the Atlantic, where they are known as the Horse Crabs, they extend from Yucatan to the coast of Maine. Dr. R. Pulleine has stressed to me the enormous abundance of these animals on this west coast of the Atlantic. Strange to say, though formerly, in Lipalian time, so extraordinarily abundant in the waters of the Pacific, no living forms of them are now known anywhere in the Southern Hemisphere. The fact that in the Adelaide Series their remains have been traced through a vertical thickness of 5,000 feet, shows that they must have lived in this region for many scores of

(1) Dr. R. J. Tillyard, F.R.S., has recently suggested to the author in view of the very primitive character of the remains, a term like *Archi-ostraca* (on the analogy of *Gigant-ostraca*, Haeckel, a synonym for *Merostomata*). Perhaps *Archi-Arachnida* might be adopted.

thousands of years, certainly long enough for the forms found in the Beaumont Quarry Limestone above to have, apparently, become differentiated from the types in the quartzites which seem to underlie the Upper Torrens Limestone. So far no trace has been observed by the author (but there has not been time for careful, systematic search) of the Merostomes in the 1,500 to 2,000 feet of strata which separate the top of the Blue Metal Limestone of Beaumont and the Devil's Elbow, near Glen Osmond, from the base of Professor Howchin's Sturtian Tillite. At the same time, it should be mentioned that Mr. C. T. Madigan has shown the author a remarkable cast of, possibly, a large limb occurring in the "Mitcham Quartzite" at the IXL Quarry, at Mitcham. It would seem, then, that as the climate changed from sub-tropical or warm-temperate to the polar climate of Howchin's Sturtian Tillite, these old arthropods were forced to migrate into warmer latitudes, not to reappear again in Australia, as far as we know, until Silurian time. In view of the fact that all the fossils hitherto collected come from more or less geologically disturbed areas around Adelaide, and that in the Flinders Ranges to the north the strata are much less disturbed and less altered, it may reasonably be expected that in the near future, more or less complete specimens will be discovered with, one hopes, at least some of the original chitin preserved.

The author, in conclusion, wishes to express his heartiest gratitude to the Council and Fellows of the Royal Society of South Australia, particularly for the initial confidence which they showed in his judgment when accepting and publishing his earlier paper. This was based on what several palaeontologists and zoologists considered to be extremely slender and insufficient evidence, evidence nevertheless sufficient, when studied in detail over considerable areas, to convince the author that his deductions were justified.

Subsequent explorations have confirmed the original views even beyond his most sanguine expectations. It is well known that the dream of the palaeontologists of today, who would seek to trace back the evolution of the higher forms of life upon the earth, in pre-Trilobite days, is to discover Arachnids of Pre-Cambrian age, and, through them, the common ancestor from which scorpions and possibly insects, together with the Merostomes, were descended—animals which modern zoologists like Versluys and Demoll consider to have been probably land animals. It may be many years before this dream is fully realized. For that consummation will be needed the devoted and patient services of many workers. Surely the rocks of the Adelaide Series offer great possibilities! It is the author's pious wish that no time will now be lost by the geological workers of South Australia in exploiting, in the interest of world science, the priceless treasures in the Adelaide hills and Flinders Ranges. They are hard to win, but to win the beautiful is ever hard!

Description of Figures on Plate I.

The figures are all of natural size except 13A, which is $\times$ 3; 13B, which is $\times$ 12; 29, which is $\times \frac{3}{5}$; and 26, which is considerably reduced.

1. Cephalothorax (?) showing sub-central eyes (?) and detached swimming (?) plate. Also trace of anteriorly situated pair of appendages. Quartzite underlying Upper Torrens Limestone, Tea-Tree Gully, near Adelaide.

2. Ventral view of cephalothorax (?), showing eyes, and dismembered portions of appendages. Blue Metal Limestone, Devil's Elbow, near Glen Osmond, Adelaide.

3. Ventral view of small cephalothorax (?) belonging to *Stylonurus* type of Eurypterid, or to a nepionic stage of some other genus. Blue Metal Limestone, Goldsack's quarries, Beaumont, Adelaide.

4. Apparently two rows of teeth and part of chela of the antenna of a possible *Pterygotus* from above quarries.

5. An endognath, possibly also an antenna. The lower end shows the notch for the pivoting arrangement of the endognath. This belongs to *Beaumontella eckersleyi,* spec. nov., Goldsack's quarries, Beaumont.

6. A remarkably well preserved appendage, probably an endognath, is shown on the right. Faint traces of possible squamiform sculpture are visible. The knob-shaped object next on the left may represent the bud of a slender endognath, or possibly the concretionary residue from a dissolved endognath. The process next on the left appears to be part of a slender endognath. Part of *Beaumontella eckersleyi,* Goldsack's quarries, Beaumont.

7. Somewhat similar appendages from the quartzite below the Upper Torrens Limestone, Tea-Tree Gully.

8. Apparently an endognath from the Blue Metal Limestone, at the Devil's Elbow.

9. A pair of the swimming legs (?) of *Beaumontella eckersleyi* showing the characteristic large spines on the posterior edge of the coxa, and a smaller spine on the outer posterior angle of the coxa, both spines serving to protect the joint between the coxa and the basos. The paddle was detached from this limb. It has been tentatively joined on at the ? ? of the figure. Goldsack's quarries, Beaumont.

10. A pair of what may have been swimming feet (ectognaths), but it is not clear that they terminated in swimming plates, and they may have been endognaths. Blue Metal Limestone, Goldsack's quarries, Beaumont.

11. Portion of large and massive coxa, showing manducatory denticles. The Arachnid (?) to which this belonged was probably at least half a metre in length. Black chert replacing the Upper Torrens Limestone, Tea-Tree Gully, near Adelaide.

12. Post-oral lip-plate (metastoma) (?). From quartzite underlying Upper Torrens Limestone, Tea-Tree Gully.

13. Inner ends of ectognaths, and metastoma (?), partly hidden posteriorly by filiform appendages. Goldsack's quarries, Beaumont.

13A. Dto $\times$ 3, with details of Merostome (?) mouth.

13B. Dc. $\times$ 12, showing "rolled" margin of ectognath on left of figure, traces of mandibular denticles. These minute structures are rendered visible through weathering. Goldsack's quarries, Beaumont.

14. Portions of the abdominal segments of a Merostome (?) from Goldsack's quarries, Beaumont.

15. Abdominal segments of an Arachnid from the black chert replacing Upper Torrens Limestone, Tea-Tree Gully. This shows the shape and thickness of the abdominal portion of the Arachnid, and the *epimera* on each side is specially massive.

16. Thoracic plates (?) measuring 80 mm. $\times$ 20 mm. from Goldsack's quarries, Beaumont.

17. Telson (?), like that of a *Pterygotus,* from dark quartzite above Upper Torrens Limestone, Tea-Tree Gully.

18. Ventral view of cephalothorax (?), showing traces of eyes (?) as well as fragments of structures connected perhaps with the antennae. Blue Metal Limestone, Goldsack's quarries, Beaumont.

19. Portion of limb, an endognath perhaps, associated with the above carapace.

20. Two abdominal segments of a Merostome (?), separated from one another by a septum-like structure crossing the tergal half of the animal. This lamina, or septum, is perforated by two openings situated in the plane of symmetry.

20A shows the proximal surface (convex side of) this septum with the central perforations and at least one epimera (?). The epimera on right of the figure is prolonged into a small limb, not visible on the surface shown.

20B is a section of A in the plane of symmetry, and shows the perforations.

21 and 21A are specially interesting as illustrating traces of small limbs attached to the epimera of abdominal segments of a Merostome (?).

Fig. 21A appears to exhibit the ventral surface of probably six abdominal segments. The collar-stud-like structure, near the centre of the penultimate segment, seems to be a cast of the perforation of the septum, like that shown in Fig. 20A. This recalls the appendages figured by C. D. Walcott, in the Smithsonian Mis. Coll., 1911-12, Vol. 57, Nos. 2 and 6, in the Eurypterid *Sidneyia inexpectans* Walcott, and those shown in *Anthraconectes* Meek and Worthen, and the spiny flanges figured by H. Woodward attached to the last three abdominal somites in *Stylonurus scoticus* H. Woodward.

Walcott has commented on a form, like *Sidneyia,* linking up the Eurypterids with the Trilobites, and the same point can perhaps be suggested in the case of the form figured in 21 and 21A.

22. A carapace of *Eurypterus remipes* Dekay, from J. M. Clarke and R. Ruedemann, Eurypterida, of New York. Pl. VI., Fig. 6, Mem. N.Y. State Mus., No. 14, 1912. This may be compared with carapace (?), fig. 1 herewith.

23. Carapace of *Eurypterus pustulosus op. cit.* C. and R. Pl. 23, Fig. 1, for comparison with Fig. 18 herewith.

24. Dorsal view of carapace of *Stylonurus myops,* Clarke, *op. cit.* C. and R Pl. 51, Fig. 2. Compare Fig. 3 herewith.

25. Dorsal view of carapace of *Dolichopterus (?) testudineus* Clarke and Ruedemann, *op. cit.,* C. and R. Pl. 57, Fig. 2. For comparison with Fig. 3 herewith.

26. *Pterygotus anglicus,* Agassiz restored. H. Woodward. Monograph of British Fossil Crustacea, Order *Merostomata.* Palaeontogr. Soc., 1866-78, Plate 8.

27. Left swimming leg of a Eurypterid viewed ventrally with the metastoma (epistoma) plate shown on the left of figure, *op. cit.,* C. and R., Plate 3.

28. From H. Woodward, *op. cit* p. 137, shows a cross section of a Eurypteroid somite illustrating the infolding of the chitinous skeleton of a tergite, along the area where two somites join one another. The tergite and sternite plates are produced to form the epimera on either side of each segment. Compare 20. A. herewith.

29. From Woodward, op. cit., part of Pl. 23. Compare *Stylonurus scoticus* H. Woodward, with Figs. 21 and 21. A. herewith.

SOME FOSSIL REMAINS FROM THE ADELAIDE SERIES OF SOUTH AUSTRALIA.

By Fredrk. Chapman, A.L.S., F.G.S., etc., Commonwealth Palaeontologist.

[Read April 11, 1929.]

Plate II.

The following notes are based on some rather obscure remains in hand specimens which Prof. Sir T. W. Edgeworth David has given to me for description.

Comprised in this series is a number of specimens of the pale blue-green, sericitic shale from Goldsack's quarries, Beaumont, at the top of the Blue Metal Limestone in the Adelaide Series. Scattered throughout the rock, and exposed on the fractured surface [bedding plane], are numerous patches of rust-stain with more or less definite or sharp outlines. Amongst these pieces of evidence of fossil organisms there are a few that seem to definitely belong to primitive brachiopods, whilst others may represent the disconnected appendages of crustacea. There is a certain group-similarity between the latter that precludes the idea of their being merely adventitious cavities in the rock due to solution alone. The supposed crustacean remains are minute and seem to run in one direction as if drifted along strand-lines, much as flotsam is seen on the tidal shore today.

Class BRACHIOPODA.

Order ATREMATA.

Genus Lingulella.

Lingulella, cf. chapa Walcott. Pl. ii., figs. 1, 2, 4.

Observations.—The schistose and metamorphosed grey mudstone of the Blue Metal Limestone, Stonyfell, shows numerous more or less ovate impressions and casts on its surface. These, I conclude, are primitive types of brachiopods, but owing to their bad preservation and deformed outlines it was difficult at first to assign even a genus, or alliance to known genera. Some of these impressions, however, appear to show a structure on the umbonal region akin to *Lingulella,* with the buttressed pedicle area, whilst the anterior region of the shell shows fine concentric ornament. The outline of the valve is elongate ovate and acuminate in the pedicle region. The surface of the shell is finely concentrically laminate. The length of the shell is about 5 mm., and the width 2·75 mm. In some points, as in the general outline, the Australian species resembles *L. chapa* Walcott (Walcott, 1913, p. 311, pl. 1., figs. 4-9).

Locality.—Stonyfell, Adelaide.

Order NEOTREMATA.

Genus Obolella.

Obolella, cf. chromatica Billings. Pl. ii., figs. 3, 5.

Observations.—Another specimen here selected from the same grey sericitic mudstone of Stonyfell may, no doubt, be referred to as a form of *Obolella.* It is a broadly trigonal shell having a wide anterior margin. The central area of the

umbonal region is ridged in such a manner as to imply the presence of a pedicle tube. The surface of the impression is marked by fine concentric lines. Probably the majority of the impressions, amounting to many a score on the large hand specimen, may be referable to this genus. Length of selected example, 3 mm.; width, 3·25 mm. The nearest allied form seems to be *Obolella chromatica* of Billings. (Billings, 1861, p. 591; Walcott, 1913, p. 313, pl. lii., fig. 2.)

Locality.—Topmost quarry, Beaumont, Adelaide.

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EXPLANATION OF PLATE II.

Fig. 1. *Lingulella,* cf. *chapa* Walcott. Numerous examples on shale. Stonyfell, Adelaide, South Australia. X circ. 1½.

Fig. 2. *Lingulella,* cf. *chapa* Walcott. Same locality. X circ. 1½.

Fig. 3. *Obolella,* cf. *chromatica* Billings. Internal mould of dorsal valve. Beaumont, Adelaide. X circ. 1½.

Fig. 4. *Lingulella,* cf. *chapa* Walcott. X 4.

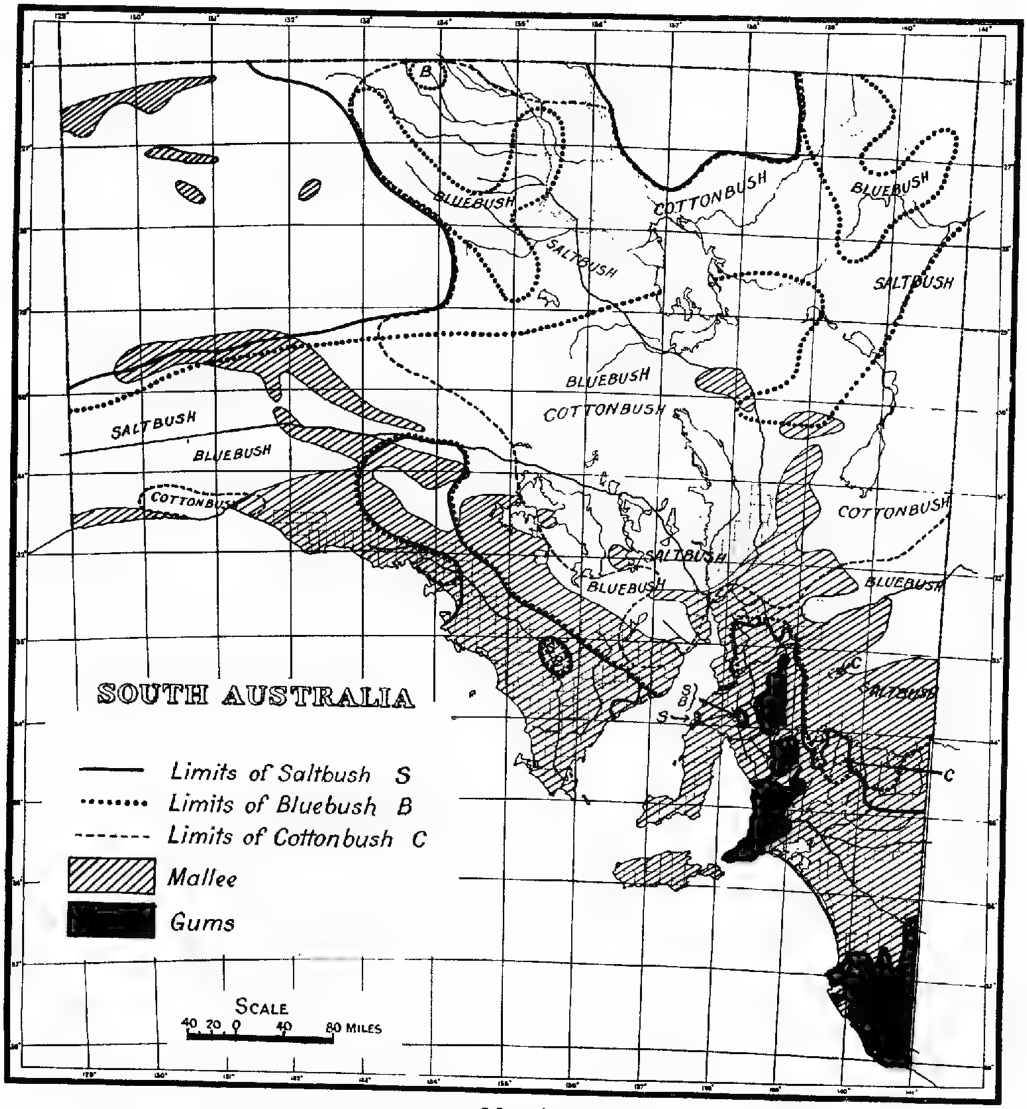
Fig. 5. *Obolella,* cf. *chromatica* Billings. X 4.

THE VEGETATION MAP OF SOUTH AUSTRALIA.

By J. A. Prescott, M.Sc.

[Read April 11, 1929.]

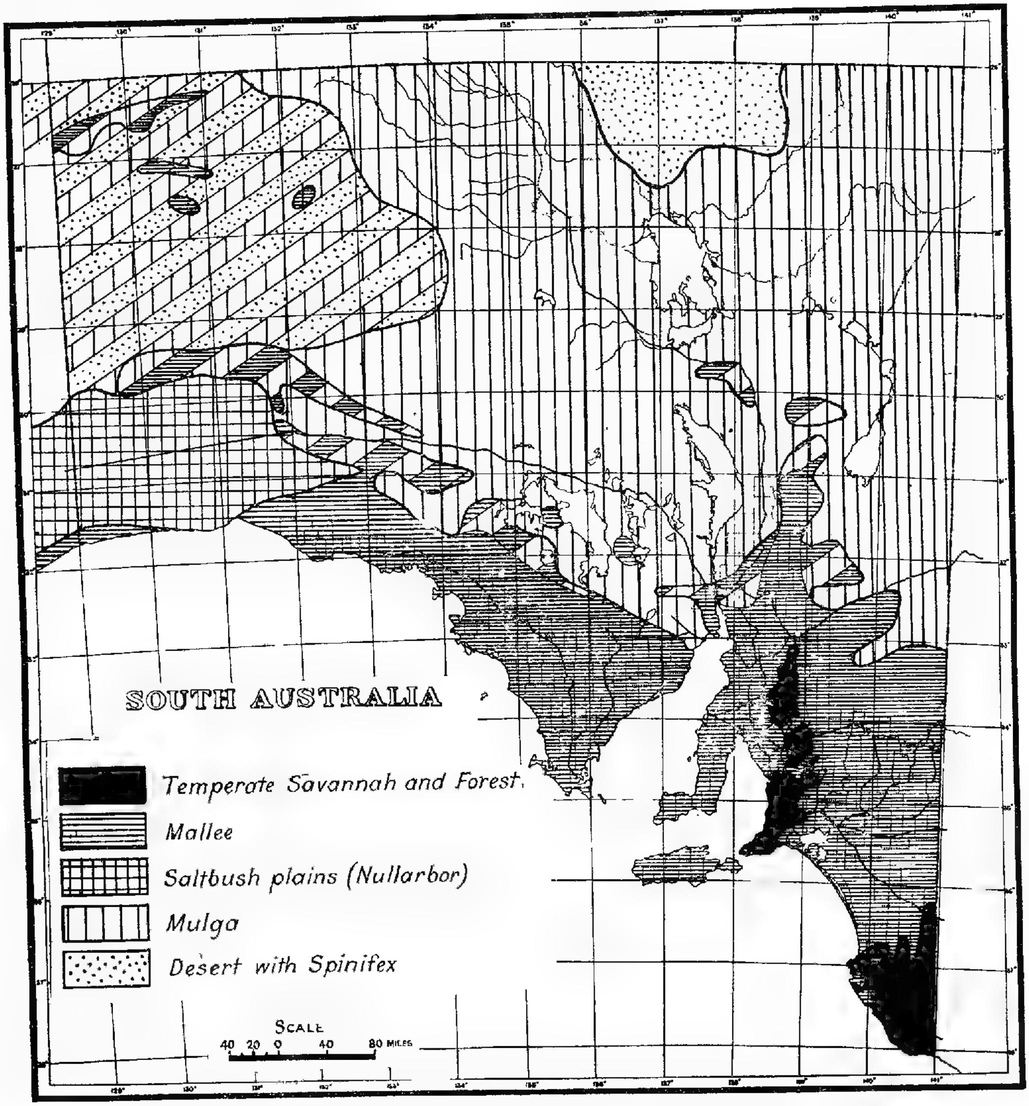
The value of the characteristic native flora, as an index of the geological, soil and climatic features of South Australia, has been recognised from the early days of settlement, and the record of the native vegetation has been a special feature of the work of the surveyors and official explorers. At the suggestion of the



Map 1.

Native vegetation of South Australia showing the limits of certain types, based on the records of the Lands and Survey Department.

writer, the authorities of the University of Adelaide, in 1926, made arrangements for the Lands Department to investigate such official records and for a map to be prepared showing the native vegetation prior to settlement. The map was completed in October, 1928, under the authority of the Surveyor-General, and a copy was made available for use at the Waite Institute in connection with the work on soil classification.



Map 2.

Native vegetation of South Australia, based on the records of the Lands and Survey Department.

The surveyors have used popular names, but there is little likelihood of confusion as these have been found to be readily understood by systematic botanists with local experience. The types recorded are, in the main, perennial shrubs and trees, but a number of the grasses are mentioned where these are sufficiently prominent to have been noticed. For the more arid areas these include spinifex

or porcupine grass *(Triodia irritans* and *T. pungens)*, cane grass *(Spinifex paradoxus)*, and Mitchell grass *(Astrebla pectinata)*. The limits of distribution of a number of the major types are recorded on the map by colour wash and hachure; these include Saltbush *(Atriplex* spp.), Bluebush *(Kochia sedifolia)*, Cottonbush *(Kochia aphylla)*, Mallee *(Eucalyptus dumosa, E. oleosa* and allied species), Tea-tree *(Melaleuca* spp.), and Sheoak *(Casuarina stricta)*.

All other types are recorded where they occur by printing on the map.

The original is too complex to be readily reproducible, but the main features have been transferred to the two maps illustrating this paper. Map 1 gives the limits of a number of the species mentioned. In map 2 an attempt has been made to revise (so far as it applies to South Australia) the map of Griffith Taylor (1), which is in itself a revision of the map of Diels (2). In 1928 a vegetation map of Western Australia was published by Gardner and Kessell (3), and the present map forms an easterly extension of that record. It is interesting to note that, whereas there is considerable overlap between the boundaries for Saltbush and Mallee, there is very little between Mulga *(Acacia aneura* and related species) and Mallee. On the wetter limits of the Mallee there is similarly a relatively small overlap between the gums and the mallee proper.

The area of higher rainfall is characterised by Eucalyptus temperate savannah or temperate forest associations typified by the STRINGYBARK FORMATION and SAVANNAH WOODLAND FORMATION of Adamson and Osborn (4).

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GEOLOGICAL NOTES FROM THE HUNDRED OF ADAMS, FLINDERS RANGES.

By Ralph W. Segnit, M.A., B.Sc., F.G.S.

[Read April 11, 1929.]

This paper deals with the geology of that part of the Hundred of Adams, Section 635, Flinders Ranges, bounded by the fence of Worumba Paddock.

The head station is situated due east of Hawker, the nearest railway centre, at a distance of approximately twenty miles.

The general topography of the country between the township of Hawker and Worumba Station, is that of a plain having slight undulations stretching for about twelve miles from the township to the slopes of the ranges, which rise abruptly from the plain. The head station is situated about eight miles inside the rugged ranges, at the foot of Mount Plantagenet, the highest point in the Hundred, and is estimated to rise about 2,500 feet above sea level.

There are two road-tracks through the ranges by which an entrance can be made to the property, the principal one (and, incidentally, the safest) being that which enters from the west along the bed of the Willows Creek.

A considerable portion of the country inside the ranges is very heavily timbered; mallee, sandalwood, and pines predominating. The timber belts have a decided tendency to follow the outcrop of the oldest rocks where the mountain slopes, as well as the valleys and plains which also have a dense covering. On the other hand, the hills and valleys formed of the newer sediments are mainly covered with grasses, and, in particular, porcupine, with isolated clumps of mallee and gums, which are usually confined to the (now) dry water courses.

A very characteristic feature is the marked dissimilarity in the contours of the ranges. Those areas composed of the older series, *i.e.*, phyllites, schists, and quartzites, present very rugged peaks and sharp faces, with bold outlines, whilst the contour of the hills formed of the newer sediments, *i.e.*, tillites, slates and quartzites is very smooth and rounded, only broken by the interbedded bands of quartzite in the slates, as seen in section B-B., fig. 1.

The strike of the range is N.N.E. and S.S.W.

The contours shown on the maps have been sketched in by the writer, as no survey maps are available. The various heights were obtained by taking prismatic compass readings and "levelling" from the three Survey Department trig stations situated on Mount Craig, Mount Plantagenet, and Warwicks Nob.

The sections given are not drawn to true scale, but are only sketched. The thicknesses of the various formations were measured on the site, where possible, and afterwards graphically determined.

No detailed petrological work has been included in the paper, which deals only with the general features observed. All bearings are magnetic.

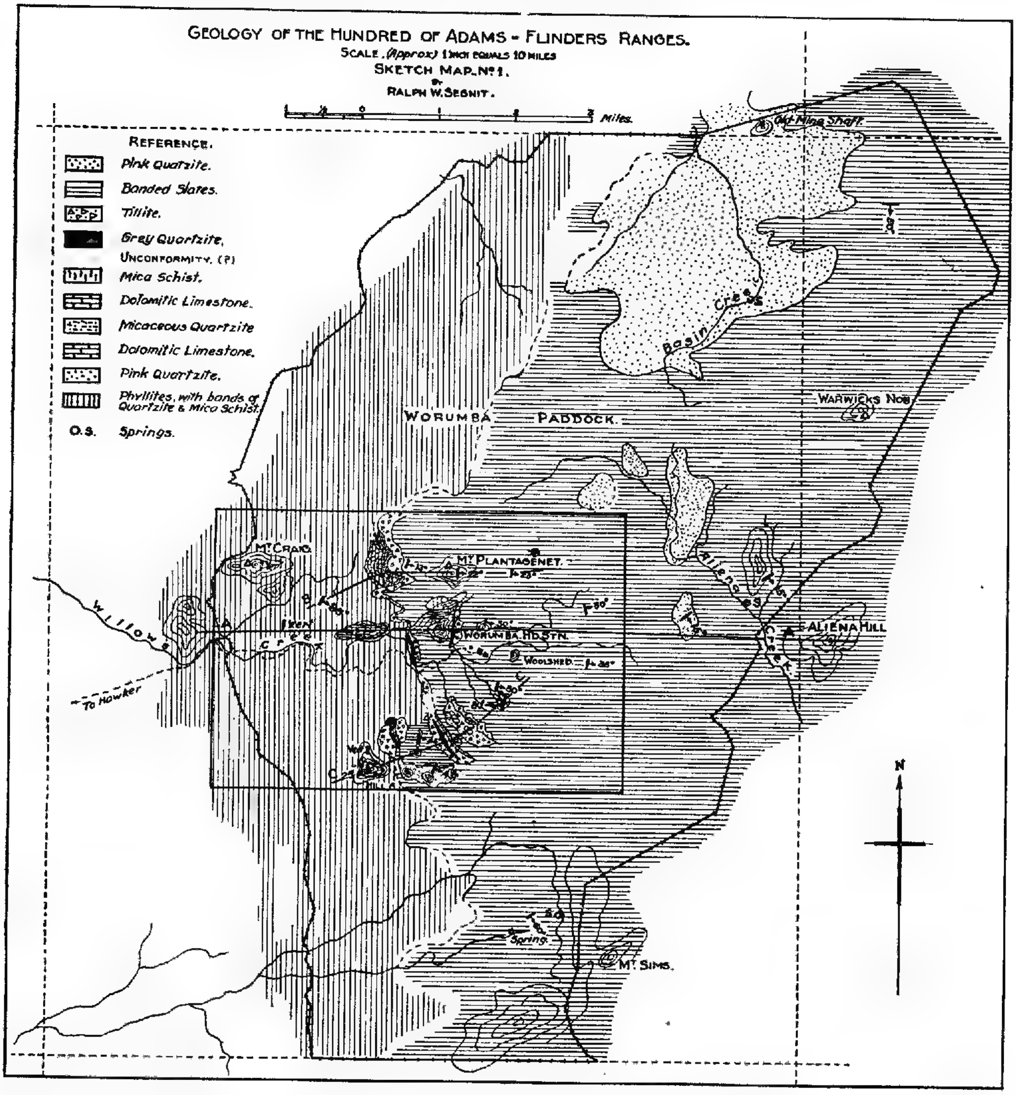
With reference to the sketch maps, No. 2 map is an enlargement of that part of No. 1 bounded by the rectangle.

Phyllites and Schists.

The oldest rocks in the locality are mainly confined to the west-central fringe of the range. On tracing their outcrops north and south from Mount Craig, their width becomes less, as the newer sediments, *i.e.*, tillites, slates, and quartzites overlap them.

Tertiary sediments rest against the older series on the west. It would thus appear that the west-central area of the Hundred was a centre of disturbance, followed by considerable erosion of the overlying sediments and exposing the underlying series.

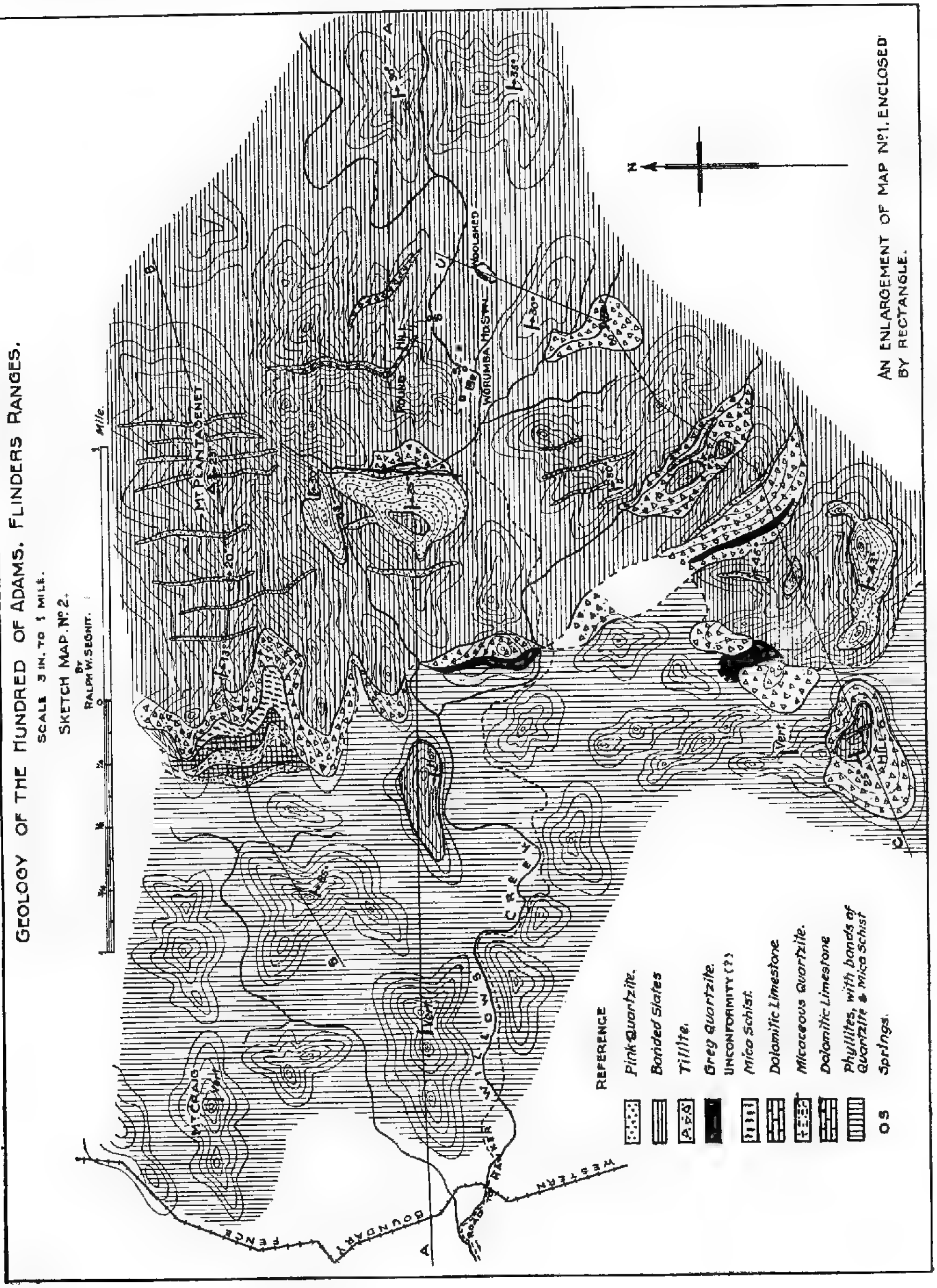
Phyllites, which are much weathered and decomposed, make up the bulk of the older rocks. These have interbedded quartzites varying from two feet to



thirty feet in thickness. The strike near the western boundary fence is mainly from 3° to 10° E. of N., and a dip which varies from the vertical to 70° E. On crossing the main strike of the range and moving eastward, the strike swings over to 15° E. of N., and dips S.S.W. at an angle of 80° as shown in a small exposure in a creek, C-C. (fig. 3), two-thirds of a mile south of the homestead, where the overlying tillite and slates have been eroded and exposed the underlying phyllites.

An outcrop of mica schist occurs on the side of a hill about one-third of a mile south of Mount Craig, having a strike due north with a vertical dip. The thick-

ness of this bed was not determined. A considerable outcrop of the same schist occurs on Mount Craig, which is composed almost entirely of this rock, with interbedded quartzites. The dip was again found to be vertical. The interbedded quartzites, wherever they crop out of the surface, form very prominent features.



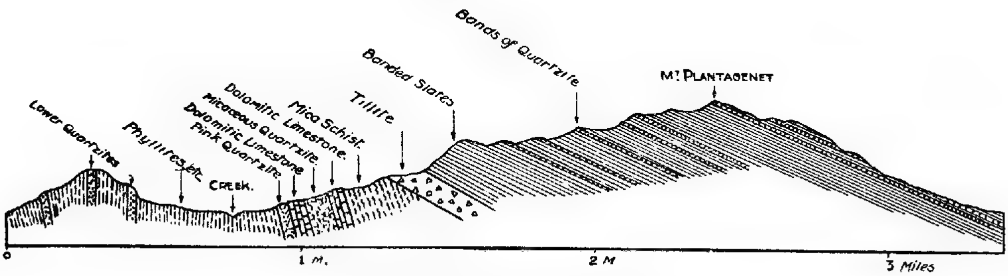
The phyllites are, again, exposed in the bed of the Willows Creek, about a quarter of a mile N.W. of the homestead. These phyllites are dipping S.S.E. at an angle of 70°.

On tracing these older beds in an easterly direction along a line as shown on Section B-B (fig. 1), a distinct series of beds was met with. After crossing the broad series of phyllites, and commencing to rise up the western spur of Mount Plantagenet, the following sequence of beds crop out at the surface in ascending order from the phyllites:—

Banded Slates	X
Tillite	150 feet
Unconformity (?)	
Mica Schist	30 "
Dolomitic Limestone	12 "
Micaceous Quartzite	21 "
Dolomitic Limestone	18 "
Pink Quartzites	10 "
Phyllites	X

All these beds up to, and including, the mica schist are conformable, the sediments showing a continuous sequence in their deposition with the underlying phyllites.

FLINDERS RANGES - HUNDRED OF ADAMS.



Section from East to West, through Mount Plantagenet (Section B-B.)
Fig. 1

Mr. Madigan (I.), in his section of the Adelaide Series, suggests a possible unconformity immediately below the Sturtian Tillite in the local series. The writer examined the junction of the tillite with the underlying beds, and found, in this region, that a distinct non-sequence occurs. Immediately south of the section line A-A., and again in the region of the section line C-C. (fig. 3), a very fine-grained bed of dark grey quartzite is found beneath the tillite, and in these cases the unconformity occurs between the quartzite and the underlying phyllites.

The unconformity may be due to an overthrust, the pressure being exerted from the east, and the tillites and succeeding beds were thrust forward in a westerly direction, overriding the underlying beds. It is interesting to note that a hill about one and a three-quarter miles east of the western boundary fence, along the section line A-A. (fig. 2), is composed entirely of banded slates, which are lying horizontally upon the upturned edges of the phyllites.

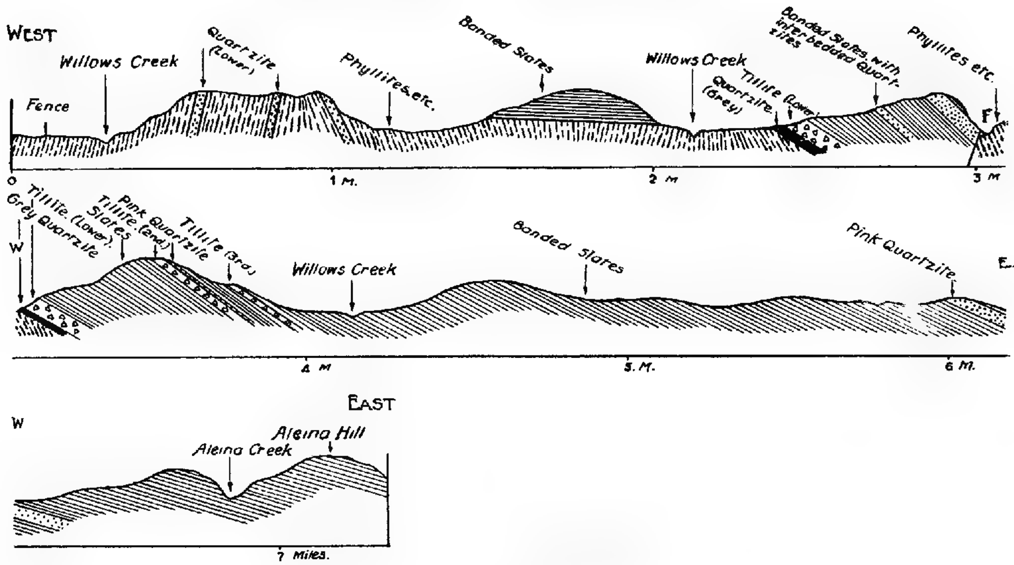
Although a careful search was made, no trace of any tillite was observed at the base of the slates nor any indication of crush rock to suggest a thrust movement.

A very rapid survey was made along the outcrop of the above-mentioned sequence of beds. Southward of the section line B-B. (fig. 1) they were lost beneath the overlapping tillites, about a quarter of a mile from the section line.

To the northward they are soon concealed by a dense covering of timber and scrub. In no other part of the Hundred was this succession of beds again met with, except the uppermost member—the mica schist.

This schist contains abundant fine flakes of muscovite and has a well-defined greenish-grey banded structure.

FLINDERS RANGES - HUNDRED OF ADAMS.



Geological Section, from West to East. Distance 7⅛ Miles.
Sketch-Section. A-A.
Fig. 2.

Grey Quartzite.

Immediately below the tillite shown in section C-C. (fig. 3) is a thin bed of dark grey, fine-grained quartzite. Reference has previously been made to the occurrence of this bed. The average thickness is six feet. This quartzite crops out very persistently beneath the tillite in this area, the exception was found on the western spur of Mount Plantagenet. Prof. Howchin (2) refers to the persistency of quartzite underlying the Sturtian Tillite.

A little to the north-eastward of Hill 6, this dark grey quartzite is seen lying beneath two isolated patches of the tillite, and is also exposed in the bed of the Willows Creek, five-eighths of a mile S.S.W. of Mount Plantagenet, lying beneath a band of tillite five feet thick.

Tillite.

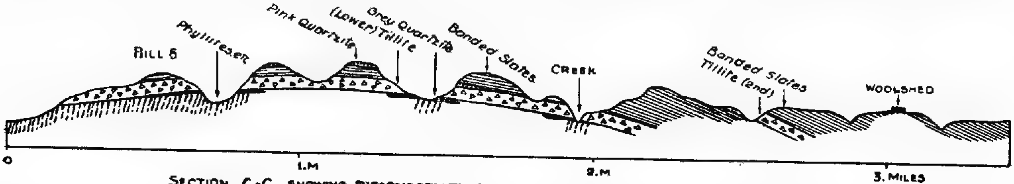
Two well-defined beds of the tillite can be recognised in the district, with an additional thin band interbedded with the banded slates higher in the series.

The lowest and principal bed, for convenience of description and reference, has been termed the "Lower Tillite." This lower tillite is composed of a very fine-grained groundmass of a light ochreous colour, containing flakes and small books of mica, which are up to 2 mm. in size. Erratics which are sub-angular, with rounded corners, are freely distributed throughout the mass. They vary in size from small pebbles to boulders measuring 18 inches by 12 inches. The erratics are mainly derived from phyllites, a pink dolomite, a granite (containing pink felspar quartz and biotite), and a fine-grained, dark grey quartzite.

A very interesting anticline occurs in the district, composed of the tillite and associated beds, which is shown in the sketch section C-C. (fig. 3). The line is

taken from Hill 6, near the western boundary fence, in a north-easterly direction to the Station Woolshed, a quarter of a mile to the east of the Homestead.

On the western side of Hill 6, the tillite dips to the S.W. at a maximum angle of 25°, with a strike of 10° W. of N. At the summit of the hill the dip of the overlying slates is 18-20°, whilst the outcrop of the tillite in a creek, about one and a quarter miles further along, the section line has a strike of 5° E. of N., and dip to the E. of 30°. Following the same section line another half-mile, a second bed of tillite is exposed in the bed of a small creek south of the homestead. The



Section C-C. Showing Disconformity between the Phyllites and Tillite Series
Fig 3

included erratics here were mainly composed of a pink granite of a very coarse-grained texture, the biotite and felspar crystals being well developed. This bed is from 40 feet to 50 feet in thickness.

The third bed of tillite referred to is indicated on the section line A-A. (fig. 2), between three and four miles from the western boundary fence. It occurs in the banded slates about a quarter of a mile north of the Woolshed, on the surface of the eastern spur of Round Hill. This bed is 6 feet in thickness. The lower tillite in this region, which has been faulted down, is about 120 feet in thickness. The second bed is 27 feet in thickness and is overlain by a bed of quartzite 8 feet thick.

Banded Slates.

The great mass of banded slates rest conformably on the lower tillite. They are characterised by bands of a pinkish quartzite, varying from a few inches to beds 20 feet thick. A feature of these quartzites is the presence of numerous veins of secondary quartz. Some of these veins are remarkably regular, and in parts form a ribbon structure. They vary from ·5 mm. to 2 cm. in thickness. On the western slope of Mount Plantagenet, just below the summit, a bed of light-coloured quartzite occurs, interbedded in the slates, with a very even-grained texture, the grains being cemented together with carbonate of lime which is undergoing decomposition.

The slates are of a very fine-grained texture, freshly cut pieces being a steel blue colour, exhibiting very fine ribbon structure. It was noticed that this ribbon effect was particularly marked where the slates were in close proximity to the tillites, and gradually faded on passing upwards in the series.

An approximate estimate of the thickness of these slates is from 2,000 to 2,500 feet. An accurate measurement could not be obtained owing to the concealment of the outcrop on the eastern plains near the boundary of the Hundred, and also to the alteration of the strike to the north of Warwick's Nob.

The strike of the slates in the vicinity of Mount Plantagenet conforms with the tillite, but at the far north-west corner of Worumba Paddock the strike swings round to an east and west direction, with a dip to the south of 50° to 60°. This alteration of strike is referred to by Prof. Howchin (3) as a feature often met with in the Flinders Ranges.

Near the south-eastern corner of the paddock, a little to the westward of Mount Sims, the slates have a strike of 20° E. of N., and a dip to the S.E. of 60°.

The slates forming Mount Plantagenet, and stretching eastward as far as shown on section B-B. (fig. 1), contain numerous erratics. Beneath the western

SEQUENCE OF LOWER ADELAIDE STRATA REPRESENTED IN THE HUNDRED OF ADAMS - FLINDERS RANGES.

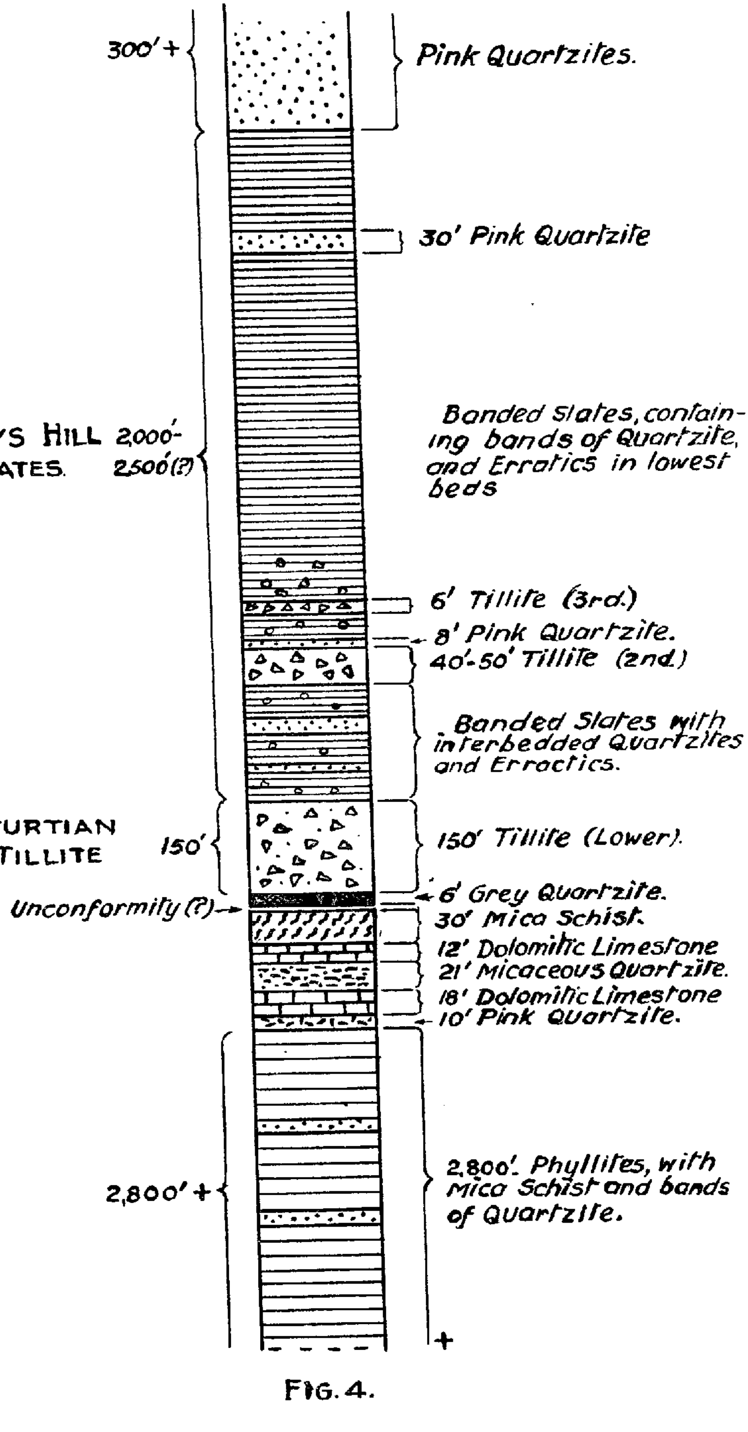


FIG. 4.

summit of the cairn on the Mount, several granite boulders, measuring 24 inches by 18 inches, are embedded in the slate outcrop. So dense are these erratics on the eastern flank, that some difficulty is experienced in defining the exact junction of the third tillite bed and the slates.

To the north of the homestead, on Round Hill, the slates weather in a distinctive manner by splitting into prisms, a feature noted by Prof. Howchin (4), west of Wilson, whilst at the eastern and southern margin of the Hundred, in weathering, they form small nodular fragments making a thin travertine crust.

Upper Pinkish Quartzites.

The rocky outcrops to the north of the Hundred, in the region of the Basin Creek, are banded slates overlain by a massive pinkish quartzite, several hundred feet in thickness. This outcrop extends to the northward of the northern boundary fence of Worumba for a considerable distance. The whole of these quartzites contain veins of secondary quartz, some veins being 6 cm. in thickness. An attempt was made to trace the outcrop along the western margin, but owing to a very dense covering of timber in this area it was not possible to do so.

At the old mine shaft dump, near the northern boundary, are fragments of ironstone. This shaft has been sunk through the quartzites.

Conclusions.

From the character, composition, and wide distribution of the Adelaide Series Tillite, in this State, it is possible for the writer to classify, on lithological evidence, the tillite in the Hundred of Adams as the "Sturtian Tillite," and the thick series of slates above them as "Tapley's Hill Slates."

At present some doubt exists in the mind of the writer in regard to the exact horizon in the Lower Adelaide Series, of the phyllites and associated mica schists and quartzites, together with the thin beds of sediments lying conformably on the phyllites on the western spur of Mount Plantagenet. If they represent the "Upper Phyllites" of the type district, then the unconformity below the tillite and grey quartzite is, probably, the representative of the mass of sediments which exist between the Upper Phyllites and the Sturtian Tillite.

The sequence of strata shown in the column (fig. 4) will not be found in any one locality in the Hundred under review, but is a representation of the total beds occurring in the district.

The thickness of the various formations, in most cases, is only approximate.

A very careful search was made in all the creeks and old watercourses for any signs of higher beds, particularly near the eastern boundary, but no evidence was seen. When standing on the top of Warwick's Nob and looking towards the east, the distant ranges in Walpalina Paddock exhibit features which point to a decided change in the nature of the rocks met with in Worumba Paddock. As there is no track or gateway through the high dog-proof fence along the eastern boundary of Worumba, the author was unable to continue the examination (across the strike) of the outcrop shown in section A-A. (fig. 2).

The writer desires to express his appreciation to Mr. G. Murray Howard, the late owner of Worumba Station, for his kind hospitality and assistance by the loan of horses to enable this hurried survey to be made.

References.

(1) Madigan, C. T.—Trans. Roy. Soc. S. Austr., vol. li., 1927, p. 407.
(2) Howchin, W.—Trans. Roy. Soc. S. Austr., vol. li., 1927, p. 350.
(3) Howchin, W.—Trans. Roy. Soc. S. Austr., vol. xlix., 1925.
(4) Howchin, W.—Trans. Roy. Soc. S. Austr., vol. xlix., 1925, p. 14.

THE AUSTRALIAN SPECIES OF CIDARIDS, PARTICULARLY OF THE GENUS PHYLLACANTHUS, AND THEIR DISTRIBUTION ALONG THE COASTS OF AUSTRALIA.

By TH. MORTENSEN, Copenhagen.

(Communicated by Professor T. Harvey Johnston.)

[Read April 11, 1929.]

PLATE III.

During a visit to the United States in August-September, 1926, I had an opportunity of seeing in the Museum of Comparative Zoology, Harvard College, Cambridge, Mass., the collection of Echinoids from the South Australian Museum, Adelaide, placed in the hands of my friend, Profesor H. Lyman Clark, for study. I was particularly interested in finding in this collection some specimens of a new species of *Phyllacanthus,* which I had recently discovered among the Cidarids of the Hamburg Museum and named *Phyllacanthus irregularis.* The discovery of this new species, the fifth of the genus *Phyllacanthus* known from Australia, had made me very interested in the problem of the geographical distribution of all these species along the Australian coasts. When shortly afterwards I met the late Director of the South Australian Museum, Mr. E. R. Waite, in Washington, I told him about this matter, and he promised to assist me in getting some additional material for the study of these forms, and their distribution in Australian seas.

After his return to Adelaide, Mr. Waite wrote to the various Australian Museums, recommending that their material of *Phyllacanthus* should be sent to me, and some time afterwards I received collections from the Australian Museum, Sydney; the Western Australian Museum, Perth; and the National Museum of Victoria, Melbourne. The Director of the Brisbane Museum had no material to offer, but induced Mr. Rainford, of Bowen, North Queensland, to send me specimens. I beg to express my cordial thanks to the authorities of the said Museums and to Mr. Rainford for thus assisting me.

The material received proved to be of very considerable interest, particularly that from the Australian Museum, Sydney, in which I found some specimens of *Phyllacanthus longispinus* (hitherto known in two specimens only), and that from the Western Australian Museum, in which I found several examples of *Phyllacanthus irregularis,* among them a fine specimen of no less than 110 mm. horizontal diameter, the largest recent Cidarid hitherto known.

The results of my examination of all this material are incorporated in my Monograph of the Echinoidea, I., The Cidaridae (1928), but as the matter has a very considerable local interest for Australia, I have thought it desirable to publish, separately, a notice of the Australian species of the genus *Phyllacanthus* and their geographical distribution, which may, I hope, lead to further investigations. Our present knowledge of their distribution along the Australian coasts is still very fragmentary, particularly their distribution along the southern coast of the continent. Fresh material, with exact information about locality and habitat is, therefore, highly desirable. This also applies to the other species of Cidarids occurring on the Australian coasts, and I am, therefore, not confining this little note to the *Phyllacanthus* species alone, but shall give a list of all the Cidarids known to occur in the Australian seas, adding a key of determination, which may, I hope, be of practical value.

It may also be useful to add a note on the preservation of these Cidarids. The best method is to put them directly in alcohol after boring a small hole or two in the hard test of the largest specimens, so that the alcohol may penetrate more easily into the interior. For smaller specimens, particularly of the more thin-shelled *Prionocidaris* species, it is not necessary, or desirable, to bore a hole in the test, which may easily result in the breaking of the test. After the specimens have been preserved for some time (at least a few weeks) in alcohol they may be taken out and dried, and they will then usually keep very satisfactorily. If directly dried after being taken from the sea, without having first been preserved in alcohol, they will soon lose their spines, and the test will fall to pieces. If alcohol (or formalin) is not available at the collecting, it is advisable to open the

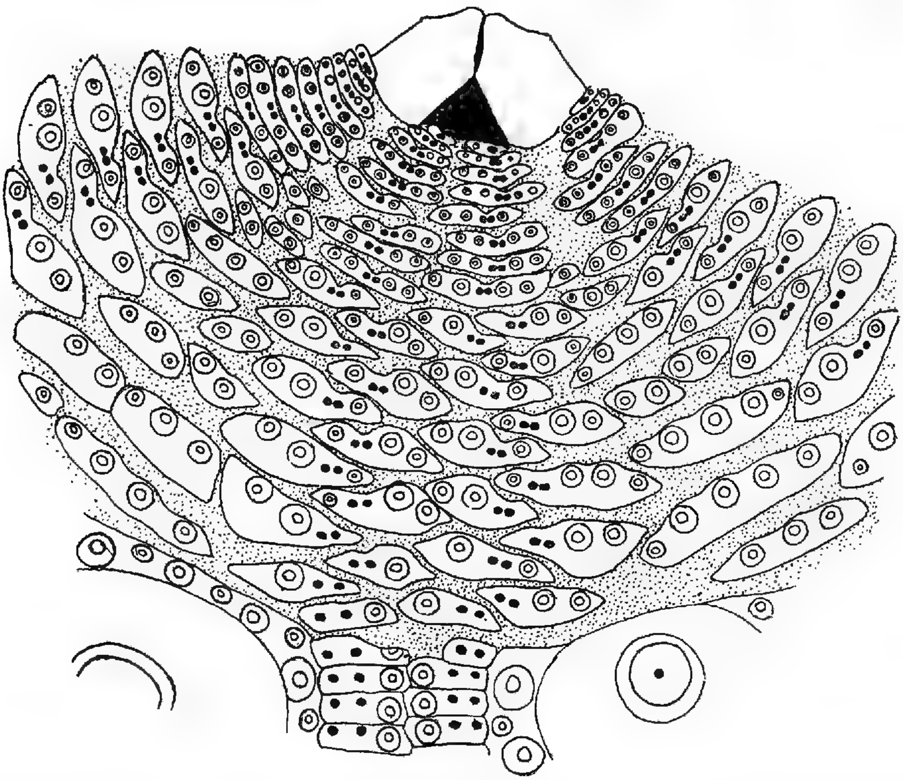


Fig. 1 × 6.
Part of peristome of a *Phyllacanthus*, showing arrangement of ambulacral pores in double series.

specimens at the mouth and to remove all the interior organs. In that way they may keep fairly well. If thus treated, the dental apparatus (the "lantern") and the peristomial membrane in which the dental apparatus remains fixed, should be replaced in the test, after it has been emptied.

The genus *Phyllacanthus* was, until recently, taken in a very wide sense, comprising such different forms as *Prionocidaris bispinosa,* with long, slender, more or less coarsely thorny primary spines; *Plococidaris verticillata,* with the thorns arranged in successive crown-shaped whorls on the short, coarse primary spines; besides *Phyllacanthus imperialis* and *parvispinus* with thick, cylindrical, smooth, thornless primary spines. The researches undertaken, in view of the preparation of my Monograph of the Cidaridae, have led to the result that the genus *Phyllacanthus* must be restricted to

those species which have thick, smooth, cylindrical spines. These species have also other important characters in common in contradistinction from other Cidarids, particularly the very interesting character that the ambulacral pores on the peristome are arranged, more or less regularly, in double series (fig. 1). A somewhat similar condition is found among recent Cidarids only in the genus *Eucidaris*. Also in the microscopical structure of the spines the said group show a marked difference from all other recent Cidarids. There can, therefore, be no doubt that these species with the smooth, cylindrical primary spines form a natural group, to which the name *Phyllacanthus* must be applied. None of the Cidarids with thorny spines can rightly be referred to this genus.

We know now, in all, six species of the genus *Phyllacanthus* as thus restricted, viz.:—

Phyllacanthus imperialis (Lamk.), *Ph. dubius* Brandt, *Ph. parvispinus* Ten. Woods, *Ph. longispinus* Mrtsn., *Ph. magnificus* H. L. Clark, *Ph. irregularis* Mrtsn.

Five of these species occur in Australian waters. One, *Ph. dubius*, is known only from the Bonin Islands, near Japan, previous records of its occurrence in the Australian and Indo-Pacific seas being due to misidentifications. Another species, *Ph. imperialis*, is distributed all over the Indo-Pacific, from Japan to Australia, and from Africa to the Tonga Islands; another, *Ph. parvispinus*, would appear to be widely distributed over the South Sea (the "*Ph. dubia*" from the Kermadec Islands seems to be, in reality, *Ph. parvispinus*). The three last are, so far as known, confined to the Australian coasts. It thus appears that the Australian seas are the true home of this genus, where it has undergone a considerable specialization, and whence it may be supposed to have spread, more or less widely, over the Indo-Pacific.

We may now see how these five species are distributed along the Australian coasts, judging from the facts hitherto available.

Ph. imperialis is known with certainty only from the Torres Strait region. The specimens recorded under the name *Ph. imperialis*, by H. L. Clark, in his Reports on the "Thetis" and the "Endeavour" Echinoderms are *Ph. parvispinus*.

Ph. parvispinus is known with certainty only from the east coast of Australia, from Shoalhaven Bight to Moreton Bay. The specimens recorded by Döderlein from Fremantle are *Ph. irregularis*.

Ph. longispinus is known only from North Australia (Cape Jaubert and Port Darwin).

Ph. magnificus.—The only two specimens known were found between Fremantle and Geraldton.

Ph. irregularis is known from Western Australia, from Fremantle to Bremer Bay on the south coast. Clark's suggestion (Rec. S. Austr. Mus., iii., p. 455, 1928) that the specimens of this species found in the South Australian Museum came from the coast of the Northern Territory, there is nothing to support. On the contrary, since this species is now known with certainty to occur on the south coast, the probability is that these specimens also came from that region.

From the facts hitherto available it would appear that each of the species occupies its own area, to the exclusion of the others, except on the south-western coasts, where *Ph. magnificus* and *Ph. irregularis* occur together. But it is quite possible that further investigations will show that the distribution of the various species is not thus restricted. At least, we may expect that their areas of distribution will be found to transgress.

It is especially a remarkable fact that, apart from the occurrence of *Ph. irregularis* as far west as Bremer Bay, at the south-western corner of Australia, we do not know anything about the occurrence of any *Phyllacanthus* species along the whole southern coast. That this does not mean that no *Phyllacanthus* species lives on the southern coast (as would seem to be the opinion of Clark) I rather take for granted, particularly since we know that a *Phyllacanthus* species occurs on the Tasmanian coasts. It is probable that the latter form will prove to be *Ph. parvispinus;* but I have had no access to specimens from Tasmania, and we can thus, for the present, only say that it is not *Ph. dubius*, under which name it is mentioned by Tenison Woods (Proc. Linn. Soc., N.S.W., ii., 1878).

All the species are littoral; the greatest depth from which any has been recorded is 73 metres *(Ph. imperialis)*; *Ph. parvispinus* has been found to a depth of about 30 metres. They prefer rocky shores, where they may be found under stones and in crevices so narrow that it is very hard to understand how they could get in (and out) with their huge spines which would seem to be anything but practical for such a life. Very probably they come out at night to feed. Their food appears to consist mainly of calcareous algae *(Corallina)* and incrusting organisms.

The other Cidarids known to occur in Australian seas are:—

Histocidaris elegans (A. Agaz.), *H. australiae* Mrtsn., *H. crassispina* Mrtsn.

Goniocidaris tubaria (Lamk.), *G.t.*, var. *impressa* Koehler,[1] *G. australiae* Mrtsn.

Stylocidaris Reini (Döderlein), *S. bracteata* (A. Ag.), *S. conferta* (H. L. Clark).

Eucidaris metularia (Lamk.),

Plococidaris verticillata (Lamk.).

Prionocidaris australis (Lamk.), *Pr. bispinosa* (Lamk.), *Pr. baculosa*, var. *annulifera* (Lamk.).

The distribution of these species is as follows:—

The three *Histocidaris* species have been found only off the New South Wales coast, in about 150-360 metres, while *H. australiae* and *H. crassispina* are known from nowhere else. *H. elegans* is widely distributed over the Indo-Pacific to Japan and the Indian Ocean.

The *Goniocidaris* species are confined to the Australian seas, *G. tubaria*, apparently, occurring all round the coasts, while the var. *impressa* and *G. australiae* appear to be confined to the Tasmanian seas and Bass Strait. *G. tubaria* is, mainly, a littoral form, while *G. australiae* is known from depths of 70-470 metres. To this latter species belong the specimens mentioned by Clark in the "Endeavour" Echinoderms as *Goniocidaris clypeata* Döderl. No doubt *G. australiae* is closely related to the Japanese *G. clypeata*, but judging from the material available they appear to form two distinct species.

Stylocidaris reini (possibly a distinct variety) is known in Australian seas only from Bowen, Queensland. This species is otherwise distributed from the Malay Archipelago to Japan, in depths of about 100-500 metres.

Stylocidaris bracteata has been recorded by H. L. Clark (Echinod., Western Australian Mus.) from between Fremantle and Geraldton, 100-180 metres. It is otherwise known only from the Malay Archipelago.

Stylocidaris conferta appears to be confined to the eastern Australian seas; it is known from off Port Jackson to Bass Strait, about 150-470 metres.

Eucidaris metularia, Plococidaris verticillata, Prionocidaris bispinosa and *Pr. baculosa*, var. *annulifera,* are widely distributed, mainly littoral Indo-Pacific

(1) Usually erroneously named *Goniocidaris geranoides* (Lamk.).

forms. *E. metularia* is known only from the northern coasts of Australia; exact Australian localities are unknown for *Pl. verticillata* and *Pr. baculosa*, var. *annulifera* (the latter having been confused with *Pr. bispinosa*), whereas *Pr. bispinosa* is known to occur from Shark Bay and along the northern coasts to Port Denison in Queensland. Finally, *Pr. australis* is known only from Bass Strait to Queensland (in 10-90 metres) and from Lord Howe Island, unless the Indo-Malayan *Pr. glandulosa* (de Meijere) should ultimately prove to be identical with it.

For a detailed description of all these species I must refer to my Monograph; but I shall here give a key for the determination of the various Australian Cidarids, by means of which it should be possible to identify them without much trouble.

Key to the Australian Species of Cidaridae.

1. Primary spines thick, cylindrical, smooth, never thorny; secondary spines fitting as a close mail around the base of the primaries; pores on peristome in double series *(Phyllacanthus)* .. 2
   Primary spines slender, smooth or thorny; secondary spines usually not fitting as a close mail around the base of the primary spines; pores on the peristome in single regular series 6
2. Adult specimens (about 50-70 mm. horizontal diameter) with 6-7 coronal (inter-ambulacral) plates in each series 3
   Adult specimens with 8-10 coronal plates in each series 4
3. Primary spines usually dark, with whitish bands; genital pores not on top of a conical elevation .. .. .. *Ph. imperialis*
   Primary spines greenish-whitish, without bands; genital pores usually on top of a conical elevation .. .. .. *Ph. longispinus*
4. Oral primaries conspicuously flaring at tip; secondary spines at base of primaries usually keeled .. .. .. *Ph. magnificus*
   Oral primaries not flaring at tip; secondary spines not keeled .. 5
5. Marginal series of ambulacral tubercles more or less irregular, the tubercles and spines of varying size; spines on apical system pointed; some larger tubercles (spines) along inner edge of genital plates .. .. *Ph. irregularis*
   Marginal series of ambulacral tubercles and spines regular; spines on apical system broad, scale-like; no larger tubercles along inner edge of genital plates .. .. *Ph. parvispinus*
6. Only tridentate pedicellariae are found, usually very large and conspicuous, the head up to 5 mm. long; no globiferous pedicellariae; primary tubercles distinctly crenulate *(Histocidaris)* 7
   Globiferous pedicellariae always present, tridentate pedicellariae often absent; all the pedicellariae of small size and inconspicuous. Tubercles smooth, at most the upper ones slightly crenulate 9
7. Primary spines with some few, irregularly arranged, coarse thorns, mainly in the basal part .. .. *Hist. australiae*
   Primary spines only with very fine, microscopical thorns, arranged in regular, longitudinal series 8
8. Primary spines very slender, cylindrical .. .. .. *Hist. elegans*
   Primary spines distinctly fusiform .. .. *Hist. crassispina*

9. Grooves at the ends of the horizontal sutures *(Goniocidaris)* .. 10
No groove 12

10. Upper primary spines ending in a conspicuous flat, round disk *G. australiae*
Upper primaries more or less trumpet-shaped, not ending in a conspicuous, flat disk 11

11. Grooves connected into a conspicuous, sunken median furrow, both in the ambulacra and interambulacra .. .. .. *G. tubaria*
Grooves isolated, in a more or less distinct, ladder-like arrangement .. .. *G. tubaria,* var. *impressa*

12. Apical system almost naked, and with a fringe of flattened spines along outer margin .. .. *Eucid. metularia*
Apical system wholly covered with small spines 13

13. Primary spines verticillate .. .. *Plococid. verticillata*
Primary spines not verticillate 14

14. Basal part ("collar") of primary spines spotted 15
Basal part ("collar") of primary spines not spotted 17

15. Collar with whitish spots, separated by purple lines *Prionocid. australis*
Collar with red or purple spots 16

16. Primary spines with sharp longitudinal ridges; pores not connected by a furrow .. .. *Stylocid. bracteata*
Primary spines not with sharp, longitudinal ridges; pores connected by a distinct furrow ("conjugate")
Prionocid. baculosa, var. *annulifera*

17. Primary spines smooth, never with coarse thorns, white, usually some of them with few narrow, sharply-marked, red rings .. .. *Stylocid. conferta*
Primary spines usually with some coarse thorns, greenish or violet, never with sharply-marked red rings .. .. *Prionocid. bispinosa*

DESCRIPTION OF PLATE III.

Fig 1. *Phyllacanthus imperialis* (Lamk.).
Fig. 2. *Phyllacanthus irregularis* (Mrtsn.).

ON THE LARVAL TROMBIDIID MITE (TROMBICULA HIRSTI L. SAMBON) THAT CAUSES THE "SCRUB ITCH" OF NORTHERN QUEENSLAND AND THE COORONG, SOUTH AUSTRALIA(1).

By Stanley Hirst

(Zoological Dept., University of Adelaide, South Australia).

[Read April 11, 1929.]

The larval Trombidiid mite known as the "Scrub Itch Mite," in Northern Queensland, was described by Louis Sambon under the name *Trombicula hirsti* in July, 1927. The original specimens were found on human beings at Innisfail, and I have since re-examined them, and also examples from Tully. The same species of *Trombicula* attacks man in the South-Eastern districts of South Australia, from Kingston to Robe, and also in the direction of Mount Gambier. During a recent visit to Robe (December 3-6, 1928), I was able to collect a large number of specimens of this mite. It is extremely abundant during the warmer months, especially January. This larval form is chiefly found amongst the undergrowth beneath the Tea-trees. It has several local names, such as "The Robe Mite," "Tea-tree Mite," and "Red Spider." Persons walking in the Tea-tree scrub, or camping therein, are often badly bitten by this pest, and sometimes severe irritation, which may last for days, is caused by its bites. It is pretty certain that this mite, known variously as the "Scrub Itch Mite" of North Queensland, and also "Tea-tree Itch Mite" of South Australia, is identical with the form described by Hatori under the name *Trombicula pseudo-akamushi.* The latter name has, however, also been used for another species by Tanaka. Further investigation of the Japanese literature is necessary before the correct name can be definitely settled.(2) The species has a wide distribution occurring in Japan, Sumatra, and the Malay Peninsula, besides Australia. So far this mite is not known to convey disease, but allied forms, viz., *Trombicula akamushi* Brumpt, and *T. deliensis* Walch, are known to transmit varieties of tropical typhus or pseudo-typhus. Another species, *Trombicula (Leeuwenhoekia) australiensis* Hirst, molests human beings in the Ashfield district of Sydney, New South Wales, and is also known to occur in Sumatra. The following is a description of this species of larval *Trombicula.*

Trombicula hirsti, Sambon.

Ann. Mag. Nat. Hist. (9) xx., pp. 157-161 (July, 1927).

Ann. Trop. Med. Parasitology, xxii., p. 67 (June, 1928).

Dorsal scutum large as in *T. novaehollandiae,* n. sp. (from D'Estree Bay, Kangaroo Island, South Australia), but although the posterior margin is convex as in that species, it is differently shaped, being cut off rather sharply (more angular) instead of rounded off gradually at the outer corners. Pseudostigmal hairs very fine and fairly long, only the distal end being plumose. Anterior lateral hairs rather slender and fairly long. The anterior median very similar to the anterior laterals. Posterior lateral hairs of scutum also rather long and slender,

(1) The cost of this and other papers on Australian Acari has been partly met by a government grant received through the Royal Society, Burlington House, London, W.

(2) In the "Key-Catalogue of the Crustacea and Arachnoids of Importance to Public Health," Washington, Hygienic Lab. Rep. No. 148, 1927, p. 269, *T. pseudo-akamushi* is considered to be a "confused species."

being slightly the longest. Hairs on rest of dorsum about the same length as those on the dorsal scutum and rather few, about twenty to twenty-four usually being present. They are arranged as follows: 2, 6, 6, 4, 2, or 2, 6, 6, 2, 2, 2. Hairs on venter few in number. Hair on galea fine and apparently plain, being without feathering. Claw of palp, bifid. There are about six plumose hairs on the tarsus of the palp, and also two plain unfeathered rod-like setae. Tarsus of first leg with a very long and fine, plain, unfeathered, tactile seta on its dorsal surface, besides the plumose hairs.

Measurements.—Length of body, 187-228 μ; length of first leg (not including coxa), 238 μ; length of second leg (?); length of third leg, 245-270 μ. Length of dorsal scutum (in middle), 60-68 μ; its greatest width, 90-97 μ. Length of anterior median hair of scutum, 45-46 μ; of anterior lateral hairs, 41-46 μ; of posterior lateral hairs of scutum, 49-54 μ; of sensory (pseudostigmal) hairs, 47-50 μ. Length of hairs on rest of scutum, 41-48 μ.

Hab.—Innisfail, Queensland (type locality). Also Tully, Queensland, and the Coorong District of South Australia, from Kingston to Mount Gambier.

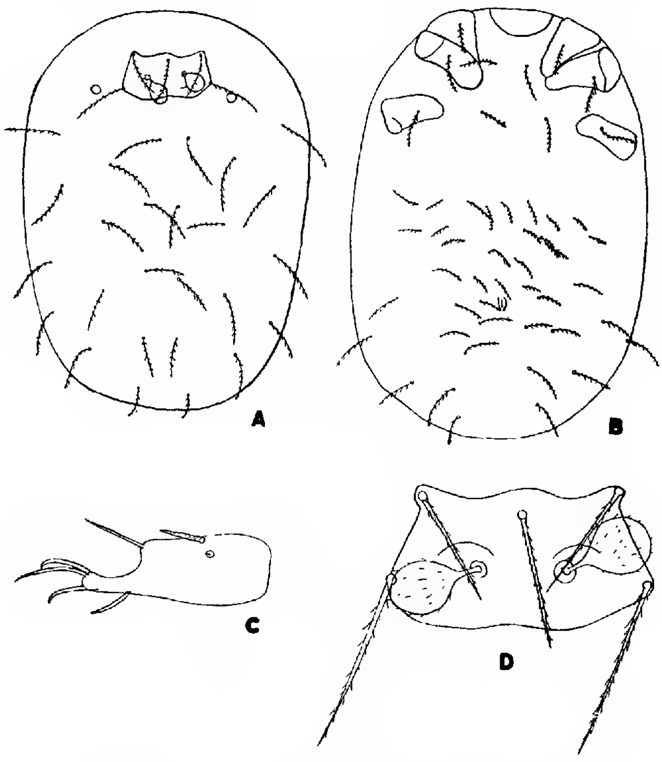


Fig. 1.

Schongastia coorongensis, n. sp.—A., Dorsal aspect of body; B., Ventral aspect of body; C., Tarsus of first leg; D., Dorsal scutum.

Schongastia coorongensis, n. sp.

A dead rat picked up in a lane at Robe by the author was found to have clusters of harvest bugs in both ears. On examination, the species proved to be

quite distinct from the Tea-tree Mite and, apparently, undescribed. The description of this new form is as follows:—

Dorsal scutum rather small and not very long, the width being slightly more than twice the length. Posterior margin of scutum shaped as shown in fig. 1. Anterior median unpaired hair of scutum longer than the anterior laterals. Posterior lateral hairs on scutum the longest. Sensory hairs with the distal end globular. Hairs on rest of dorsum about twenty-eight to thirty-two in number and arranged in rows as follows:—2, 6, 6, 6, 6, 4 or 2. There are about thirty-six to thirty-eight hairs on the venter, not including the two pairs between the coxae. Hair on galea very fine and plain, apparently being without any side hairs. Proximal segments of palp furnished with hairs which are fine and provided with only a few side hairs. Hairs on penultimate segment of palp very fine and, apparently, without any side hairs. Two or three stiff, plain, unfeathered setae are present on the palpal tarsus, and there are also four or five plumose hairs. Tarsus of first leg high, not tapering gradually. There are no plain hairs on the last tarsus, all being feathered.

Measurements.—Length of body (distended specimens), ·41 mm.; its width, ·21 mm. Length of dorsal scutum (in middle), 40-44 μ; its width, 82-90 μ. Length of sensory hairs of scutum, 29-32 μ; length of distal end of sensory hairs, 23-25 μ. Length of anterior median hair of scutum, 44 μ. Length of anterior laterals, 41-45 μ. Length of posterior lateral hairs of scutum, 58-66 μ. Length of hairs on rest of dorsum, 39-52 μ. Length of first leg (not including coxa), 219 μ; of second leg, 173 μ; of third leg, 231 μ.

Hab.—Robe, South Australia. Numerous specimens in the ears of rodent *(Rattus lutreola).*

ON THE PROBABLE OCCURRENCE OF THE STURTIAN TILLITE NEAR NAIRNE AND MOUNT BARKER.

By Professor Walter Howchin, F.G.S.

[Read May 9, 1929.]

Mr. R. Lockhart Jack, Assistant Government Geologist, drew my attention to one of the field maps of the late H. Y. L. Brown, on which he had written the word "Ice" on the site of a railway cutting situated a little to the westward of Nairne. Mr. Jack kindly motored me to the spot and, on examination, a subangular quartzite was obtained that measures 9 inches by $4\frac{1}{4}$ inches with a circumference of 16 inches. This stone was firmly embedded in a white kaolinized slate.

For the purpose of further observations, the writer paid a second visit to the spot and examined all the cuttings on the line between Nairne and Mount Barker Junction, a distance of four miles. This was done with the object of examining the associated rocks, in relation to the supposed tillite, for corroborative evidence, if possible. The geological features of these railway cuttings will be briefly described and advantage will be taken to utilize observations previously made by the writer in the district that may bear upon the same subject.

Remarks on the Railway Cuttings.

First Cutting, situated on the line about one-third of a mile westward of the Nairne railway station. Finely laminated kaolinized slates, very regular in bedding and banded in bluish and white layers, resembling a ribbon slate [(?) Tapley's Hill horizon]. Varies in dip from 65° to 90°, easterly. The rock frequently shows segregations, after the manner of spotted or knotted schist. The length of the cutting is about 10 chains. Towards the western end, three dykes of pegmatite cut obliquely across the bedding in a south-easterly strike. The most easterly one is about 18 inches in thickness, on either side of which the slates are slightly hardened but have suffered no further metamorphism. At a distance of 15 feet westward of the dyke, just mentioned, is a much larger one, having a thickness of 33 feet with a hade of about 65° to the north-east. This has caused a higher degree of contact metamorphism on the adjoining slates; those abutting on the upper plane of the dyke are definitely indurated in a zone of several inches, and the underlay has the form of a conspicuously spotted and knotted schist. The knotted segregations attain the size of a large pea [(?) incipient andalusite] which, in places, weather out and accumulate at the base of the cliff. This effect is produced over a zone of 15 inches bordering the granite dyke. A third pegmatite dyke, still further to the westward, about 18 inches in thickness, has features similar to those already described. All the dykes cut the beds without displacement.

Between this cutting and the next is an embankment about 200 yards in length.

Second Cutting. In this exposure, which is about 60 yards in length, the banded structure seen in the first cutting is absent, and bedding planes are either non-existent or indistinct, but the bed is strongly jointed in all directions. It is towards the western end of this cutting that the supposed tillite occurs. The evidence at present is mainly from the presence of subangular stones irregularly distributed through the mass after the manner of glacial erratics. In addition to the large quartzite (?) erratic, mentioned above, five other subangular stones were collected, consisting of quartz and quartzites, varying in size from one inch to

three inches in length. The matrix, when washed down, left a residue of rather fine-grained sand.

At the western end of the cutting is a fine-grained quartzite, six yards in thickness, dipping easterly under the slates [or (?) tillite] exposed in the cutting. On the supposition that the latter represents a decomposed tillite, this quartzite would correspond to the subglacial quartzite which commonly underlies the Sturtian Tillite. The exact position of the bed can be determined by the north and south district road with "open crossing" shown on the official map (although now closed) which makes the western boundary of Section 4431, Hundred of Macclesfield. The surrounding ground is grass-covered and the rocks obscured thereby, so that the bed in question is limited in exposure to the railway cutting, and, the supposed erratics having been gathered from the face, there is a danger that the superficial evidences will be possibly absent for a time.

There follows (on the western side of the last-named cutting) an embankment, ten chains in length, that spans a small creek that passes beneath the railway.

Third Cutting. This is excavated, mostly, in rotten kaolinized slate, the line following, for a time, along the strike of the beds. At the eastern end of the cutting is a 5-feet quartzite, underlain by a rotten sandstone, 24 feet in thickness. This is, again, underlain by the kaolinized slate, in which an important quartzite is included. The latter forms a low scrubby hill on the northern side of the line (in Section 3827A), is nearly perpendicular and has been quarried along the outcrop.

Fourth Cutting. By a northerly bend of the railway, the quartzite mentioned in the last paragraph is, in the next cutting, intersected by the railway. At this point, as on the hill, the bed is nearly vertical, with a slight easterly dip, and has a thickness of about 30 feet. An interesting feature of this quartzite is its piebald appearance, having a close resemblance to the mottled structure of the Mitcham quartzite, and probably represents the same horizon.

From this point, westward, to the Mount Barker Junction, there is little variation in the character of the rocks. They consist chiefly of light-coloured kaolinized slates with an occasional thin quartzite which is also much decomposed. The slates are, perhaps, less metamorphosed, on the whole, in this part of the section, but zones of slates that are spotted or knotted still occur. The beds are generally very highly pitched with acute anticlines and, probably, also, with closed anticlinal folds. In the third cutting from the Mount Barker Junction station is a pegmatite dyke, one foot wide, which is contorted with the slates but produces no appreciable contact metamorphism. At the railway station, the beds in the cutting are kaolinized, laminated, highly variegated in colour, with contorted lines. Dip, W. 20° S. at 80°.

A Belt of Limestone.

(Observations made during the Years 1907 and 1908.)

If the No. 1 cutting, westward of Nairne railway station, represents the horizon of Tapley's Hill slates, as suggested above, we might expect a limestone to occur at the next bed in ascending order, in accordance with the sequence seen in the type district. A limestone does occur in this position which may be assumed (if our deductions be correct) to represent the Brighton limestone. The ground which separates No. 1 cutting from Nairne, in a length of about a third of a mile, is low ground and grassed and destitute of rocky outcrops. In a visit which the writer made to Nairne, in 1908, Mr. Clezy, a resident of West Nairne, stated that in sinking a well on his property a bed of marble was struck at a depth of 60 feet, but I was unable to discover any surface features that might confirm this statement.

There is, however, a series of outcrops of marble which, in an almost direct line from Nairne, in a N.N.E. and S.S.W. direction, extends for about 12 miles and shows, at least, ten distinct outcrops.

In a traverse along this line of strike from Nairne it was found that the pegmatite dykes seen in No. 1 cutting made prominent exposures across the adjoining paddock, as far as the main road to Littlehampton, a distance of about a quarter of a mile. After crossing the main road, just referred to, the ground is cultivated with no rocks showing at the surface for rather less than a mile. At about one and a quarter miles from the railway a small quartzite quarry was met with, the stone being softish and of a purplish colour, with a dip E. at 50°. Shortly beyond, more on the rise and about due south from Nairne, a strong outcrop of a basic intrusive rock makes a conspicuous feature, situated north-westerly from the Mount Barker, from which it is distant about a mile with a strike directed towards the Mount at S. 20° E. The exposure is about 28 yards wide and was traced for nearly a mile. On the western side of the dyke the rock is a dark, siliceous-looking stone; on the eastern side is a wide belt of strongly-developed mica schists, knotty, with a wavy structure, caused by the knots. The marble exposures are as follow:—

1. A little to the westward of the basic dyke, just described, a marble is seen to outcrop in a low position in the paddocks of Mr. Ryder (Section 4441 and 3829, Hd. Macclesfield). In the first-named Section a small opening has been made that has exposed the rock-face which was followed along the south side of a small creek. Dip at the quarry, E. at 65°. The marble is underlain by a strong quartzite, and on the road that passes Ryder's, going to Littlehampton, thick beds of spotted slates are seen. These were followed, going westerly, but they became obscured under a thick deposit of soil towards the bottom of the valley at the first four cross-roads. Immediately west of the cross-roads the ground rises into successive ridges of hard, felspathic, and, usually, fine-grained quartzite [(?) Mitcham horizon]. In one or two places a small opening has been made in these quartzites, showing what appears to be a dip E. 10° S. at (?) 65°. The quartzites show outcrops for about a mile but are interrupted by stretches of deep soil that hide the underlying rocks. About one mile on the eastward side of Littlehampton, clay slates are seen exposed, feebly spotted in places. At the back of Littlehampton there is a quarry of kaolinized rock, variegated in colour, with a dip S.W. at 70°, which is also visible in the main street of the township. This clay-slate has been extensively used for brick-making in the neighbourhood.

2. About a mile to the southward of Ryder's, a limestone is noted on my field map as occurring in Section 4449, but have no particulars concerning it.

3. A marble is worked on the southern side of the Mount Barker Creek, in Section 4456. It crosses the road into Section 4455, and can be traced to the creek, just below the bridge, but is not seen on the northern side of the creek. The quarry stone is in two divisions, the upper portion being of a coarsely crystalline nature, whilst towards the lower portions the limestone becomes streaky and crypto-crystalline. Dip E. at 33°.

4. In the neighbourhood of Wistow are several exposures of marble. In Section 2918 (Ellis', late Mills', property) the marble is coarsely crystalline, with some impure beds in it which have thicknesses up to 18 inches. Dip E. 20° S. at 12°. The marble is overlain, as well as underlain, by quartzite, the latter of which can be seen in an adjoining quarry. The lower quartzite has dark lines in it and has clastic felspar interstitial with the quartz grains. At Eden Park (close to the above) the overlying quartzite can again be seen; also a soft, purple-coloured, argillaceous, or argillo-arenaceous rock, with no particular grain, but strongly variegated and has concentric and tortuously concentric lines. The stone works freely, and has been much used in the neighbourhood as a building stone. The bed

is massive and obscure in its direction of dip, but it probably overlies the quartzite (just mentioned), and at a low angle.

5. About half a mile to the southward of the last-named outcrop of marble is another, exposed in a small creek in Section 2895 (or thereabouts). The stone is similar to the rest in the neighbourhood but has not been worked.

6. In another half-mile, to the southward, the most important exposures of the marble in the district occur in Section 2915, where there is a quarry face of about 30 feet, having a dip S. 20° E. at 10°. It is situated a little to the eastward of Philcox Hill railway station. On a hill, between the marble quarries and the railway station, is a freestone quarry—soft and of a purplish colour—probably of the same horizon as that of Eden Park, mentioned above. Dip S. 20° W at 15°. A little further to the south-westward the marble is again seen in the bed of a small creek in Section 2828.

7. In a little more westerly trend the marble passes on the western side of Macclesfield, at a distance of about four miles from the previously noted outcrop, and has been extensively worked.

8. At a further distance of two miles, on the same line of strike, is another exposure of marble on Mr. Lemar's property, in Section 3343, on the south-western boundary of the Hundred of Macclesfield.

The limestone has thus been proved to extend for 12 miles in a direct line.

Geological Observations made to the North-westward of Mount Barker Junction.

(Dated June 5, 1908.)

The railway line was followed in a north-westerly direction. Half a mile from the railway station, in Section 4216 (Hundred of Onkaparinga), cuttings exposed decomposed phyllites with a zone of spotted and knotted schist and a granular felspathoid rock. Numerous flat veins of rotten actinolite occur with selvaged crystals at right angles to the walls, which are sometimes divided by a central line, having a thickness up to two inches. This cutting continues to the "open crossing" on the north-western side of Section 4216 (Hundred of Onkaparinga). Strike of the beds in cutting, N. 10° W., dip westerly at 70°. Strong reefs of quartz penetrate these rocks.

The road at the crossing was then followed, going in a north-easterly direction. The road, on the rise, shows low exposures of dark-coloured schists, some of which is a fine-grained biotite schist. Thin bands of dark-coloured, fine-grained quartzite occur, often laminated. Two loose specimens of tremolite schist were found on the road, probably brought with road metal, but were of good size. Near the summit of the rise a number of large stones of arkose grits were observed on the side of the road, which had apparently been gathered from the ploughed land on the western side of the road.

At a distance of one mile from the railway the road descended nearly opposite Mr. Borcher's house (Daisy Hill Farm) in Section 1775. Near the house is a quarry in the basal grits, carrying dark lines of clastic ilmenite, with a strike N. 20° W., dip vertical. The beds show current bedding and, on some faces, ripple marks. This quarry is at the end of a ridge which runs in a nearly north and south direction. Nearer the house, by the side of a private road, there is another outcrop of the same rocks, where the dip is reduced to 40° S.W., and the strike swings round to the eastward and the dip becomes southerly.

Near the highest point of the ridge, about a quarter of a mile from the house, there is a strong outcrop of felspathic quartzite with much clastic ilmenite, having a dip N.E. at 82°. The stone has been quarried and works freely. Most of the

buildings on the farm have been constructed from stones won from the quarries mentioned. The whole ridge from Borcher's consists of this rock, it has an extensive width and is to all appearance identical with the ilmenitic basal grits of the Aldgate Series. The ridge ends abruptly to the northward, overlooking the Oakbank country and the valley of the Onkaparinga. It has a height of 150 feet above the Mount Barker Junction railway station.

The Pre-Cambrian schists border the ilmenitic grits, on their eastern side, and form a higher ridge in that direction. They follow the grits, on their eastern limits, down into the angle formed by the twisted ridge of the grits, near Borcher's. In the Pre-Cambrian area several shafts have been sunk in Sections 4260 and 4264, named the New Eclipse, Balhannah Surprise, etc., from which a little gold was won.

A porphyritic basic dyke occurs in the neighbourhood but is not seen in outcrop. Mr. Borcher says it is situated on the low ground bordering the western side of the basal grits ridge. Its presence is indicated by loose stones on the surface of cultivated land—these are gathered and used, locally, as road metal.

The Sturtian Tillite near Mount Barker Township.

A few years ago Mr. R. L. Jack picked up two loose stones on the grounds of the Convent school, near Mount Barker, that show a striking resemblance to the ground-mass of the Sturtian Tillite. Both these specimens contain pebbles of granite that are undoubtedly erratics. Mr. Jack was not able to discover the parent rock from which the specimens had been shed. The ground has a low situation and the rock may be easily obscured by cover. Subsequently, the writer paid a visit to the spot, but could obtain no further evidence on the Convent grounds.

On the road, opposite to the entrance to the Convent grounds, is an old quarry (now used as a tip for the town), the main road of which is an unstratified, sandy mudstone, gritty in places. Imbedded in the mudstone stones were sparingly scattered that measured up to five inches in diameter. These consisted of quartz, quartzite, schist, and an aplite five inches in length. The last-named is somewhat decomposed. The ground-mass of the bed is, apparently, identical with that seen in the two specimens collected by Mr. Jack in the adjoining paddock, but is not quite so indurated, having been subjected to greater weathering. The mudstone, in the quarry mentioned above, is overlain by a rotten quartzite [dip S.W. at 55°], which is slightly fissile by the presence of mica on the planes of bedding. On the opposite side of the quarry the mudstone slopes with the ground to normal level and is hid from view by superficial deposits.

The overlying quartzite continues into the grounds of the Convent school, the buildings of which have been constructed on a platform cut in this rock. Going easterly, the quartzite continues in outcrop, but at a short distance there is a considerable quarry in the face of the scarp, looking south. The rock consists of highly-coloured clays and sand rock, in yellows and reds, with a thin covering of quartzite [dip S. at 55°]. The general dip of the country varies from south to south-west.

An important feature is that the two supposed outcrops of tillite are situated on the same line of strike.

Conclusion.

There is strong circumstantial evidence for the occurrence of the Sturtian Tillite at the two localities mentioned in this paper. The country concerned is mostly grassland and but slightly incised, so that it offers few opportunities for determining the geological features, the railway cuttings providing most of the

exposures available for this purpose. These cuttings are separated by embankments crossing grassed valleys that show no outcrops.

The evidences are cumulative and are based, partly, on the lithological characteristics of the supposed tillite, and, partly, on the associated beds which show a close accordance with the series in which the tillite is known to occur.

In taking a more extended view of the geological field, it appears that the basal beds of the Adelaide Series, on the eastern side of the Mount Lofties, follow a series of rolling curves from Aldgate to near the Mount Barker Junction, with the coarse ilmenitic grits at the base, passing up into a finer light-coloured sandstone. These continue for several miles, and, in places, pass up into higher horizons of kaolinized slates and stronger beds of quartzite, but without rising far in the series. Near the Mount Barker Junction, the tectonic curves become more acute, the bottom grits are folded down at a high angle—vertical in places—and the superior beds follow in sequence, at similar high angles, through the succession of lower phyllites, the Mitcham quartzite, the tillite, the ribbon-slate of Tapley's Hill, and then the Brighton limestone, which occurs at intervals, maintaining an approximately similar strike for a distance of 12 miles.

In comparison with the type district, the eastern series has, in its surface exposures, become shortened from 12 miles to 5 miles. This may possibly be explained from the apparent absence of some beds in the eastern series which are present in the western, and also from the thinning of others that are present.

In such a comparison it must be allowed that the series on the Adelaide side is superficially lengthened by a considerable rolling of the beds, while that on the eastern, between Mount Barker Junction and Nairne, is compressed almost to the vertical.

CRUSTACEA FROM PRINCESS CHARLOTTE BAY, NORTH QUEENSLAND. THE ISOPODA AND STOMATOPODA.

By Herbert M. Hale, Curator South Australian Museum.
(Contribution from the South Australian Museum.)

[Read May 9, 1929.]

Early in 1927 the writer, in company with Mr. N. B. Tindale, spent some weeks in Princess Charlotte Bay; although only a small portion of this time was occupied in marine collecting, a goodly number of Crustacea was obtained. Most of the marine material was secured on or near the Flinders Islands, a small group lying at the southern end of the bay. The "Alert" visited these islands in 1881, and since then other vessels also, but apparently little collecting has been undertaken there. A passage between Flinders and Stanley Islands—Owen Channel—has a bottom of mud and sand which harbours various dingy species, and this was systematically worked with a small dredge, while collecting was also carried out on *Halimeda* and other reefs, and amongst coral.

The present paper records the few species of Stomatopoda and Isopoda secured.

STOMATOPODA.

Family SQUILLIDAE.

It was found that an excellent method of obtaining Squillids from pools left at low tide was to introduce a small quantity of formalin. As the latter penetrated to the innermost crevices of the rock, or into burrows in the mud, the mantis-shrimps left their retreats and were easily captured with a small net. In some cases nearly an hour elapsed before all Squillids in a pool were ejected by the formalin.

The Walmbariya natives, living on Flinders Island, are well aware that these animals are capable of inflicting wounds with the spiny telson and raptorial dactylus, and on several occasions warned me that they should be handled with care.

Gonodactylus trispinosus Dana.

Gonodactylus trispinosus Dana, U.S. Expl. Exped., Crust., 1852, p. 623; Kemp, Mem. Ind. Mus., iv., 1913, p. 180 (and syn.); Balss, K. Sv. Vet. Handl., lxi., 1920, p. 5; Hansen, Siboga Exped., Leiden, Mon. xxxv., 1926, p. 35.

Protosquilla trispinosa Borrad., Proc. Zool. Soc., 1898, p. 34, pl. v., figs. 1, 1A.

Taken from tunnels in stones dredged in Owen Channel, 3 faths. The examples agree well with the descriptions, excepting that the lateral margins of the last thoracic segment are subacutely rounded, and not broadly rounded as figured by Borradaile and mentioned by Kemp. The species was previously recorded from Australia:—Swan River, Western Australia (Miers), and North-West Australia (Pocock and Balss).

Gonodactylus glabrous Brooks.

Gonodactylus glabrous Brooks, Rep. Voy. "Challenger," xvi. (Stomatop.), 1886, p. 62, pl. xiv., fig. 5, and pl. xv., figs. 7-9; Kemp, Mem. Ind. Mus., iv., 1913, p. 167, pl. ix., fig. 113 (and syn.), and p. 170, fig. 2; Odhner, Goteborgs Kungl. Vet.-Och Vitt. Samh. Handl., xxvii., 1923, p. 8; Hansen, Siboga Exped., Leiden, Mon. xxxv., 1926, p. 29.

Dredged in Owen Channel, 3 faths., and in burrows in mud near shore at low tide.

Gonodactylus chiragra (Fabricius).

Squilla chiragra Fabr., Species Insect., i., 1781, p. 515, and Mantiss. Insect., i., 1787, p. 334.

Gonodactylus chiragra Kemp, Mem. Ind. Mus., iv., 1913, p. 153, pl. ix., fig. 10 (and syn.); Balss, K. Sv. Vet. Handl., lxi., 1920, p. 5; Odhner, Goteborgs Kungl. Vet.-Och Vitt.-Samh. Handl., xxvii., 1923, p. 8; Hansen, Siboga Exped., Leiden, Mon. xxxv., 1926, p. 24.

In holes in fragments of rock dredged in Owen Channel, 1 fath.; also both adults and young common in burrows in mud near shore.

Gonodactylus pulchellus Miers.

Gonodactylus trispinosus, var. *pulchellus,* Miers, Ann. Mag. Nat. Hist., (5) v., 1880, p. 122.

Gonodactylus pulchellus Kemp, Mem. Ind. Mus., iv., 1913, p. 177, pl. x., fig. 117, 118 (and syn.); Hansen, Siboga Exped., Leiden, Mon. xxxv., 1926, p. 33.

Dredged in Owen Channel, 3 faths. Apparently this pretty species has not been recorded previously from Australian waters.

Pseudosquilla ciliata (Fabricius).

Squilla ciliata Fabr., Mantiss. Insect., i., 1787, p. 333.

Pseudosquilla ciliata Kemp, Mem. Ind. Mus., iv., 1913, p. 96 (and syn.); Hansen, Siboga Exped., Leiden, Mon. xxxv., 1926, p. 17.

A male and two females from burrows in mud near shore. Two of the specimens were mottled with brown and black during life, and one, an adult female with the fifth and sixth abdominal segments and telson abnormal, was coloured as follows:—Dorsum, dark bottle green; dactyli of raptorial legs, brown; remainder of all external appendages, pea-green with pink fringing hairs.

ISOPODA.

At the Flinders Islands, Isopods are poorly represented as regards number of species, although a few forms were abundant.

Family EURYDICIDAE.

Excirolana orientalis (Dana).

Cirolana orientalis Dana, U.S. Expl. Exped., Crust., xiv., 1853, p. 773, pl. li., fig. 7.

Excirolana orientalis Hale, Trans. Roy. Soc., S. Austr., xlix., 1925, p. 156, fig. 14 (and refs.).

Common in the mangrove swamps, where I collected specimens by standing in the shallow water and picking the little carnivores off as they attacked my bare legs. The Walmbariya natives are sometimes annoyed by the attacks of this sea-louse, which, however, they do not distinguish from *Hippa,* calling both "meljeri."

E. orientalis also burrows in sand at the margin of the sea, and the aboriginal children, aware of this habit, obtain both it and *Hippa* by scratching rapidly in the sand at the edge of the water, thus uncovering the buried crustaceans.

Family AEGIDAE.

Rocinela orientalis Schioedte and Meinert.

Rocinela orientalis Sch. and Mein., Naturh. Tidsskr., (3) xii., 1879, p. 395, pl. xiii., figs. 1-2; Hale, Trans. Roy. Soc., S. Austr., xlix., 1925, p. 182, fig. 27 and refs.).

Dredged amongst weed in Owen Channel, 3 faths.

Family SPHAEROMIDAE.

Mr. Baker identifies the few species secured as follows:—

Exosphaeroma intermedia Baker.

Exosphaeroma intermedia Baker, Trans. Roy. Soc., S. Austr., i., 1926, p. 249, pl. xxxix., figs. 1-8.

Dredged amongst weed in Owen Channel, 3 faths. The type was from the Gulf of Carpentaria.

CYMODOCE PELSARTI Tattersall.

Cymodoce pelsarti Tatt., Journ. Linn. Soc., London, xxxv., 1922, p. 15, pl. ii., figs. 30-33, and pl. iii., fig. 36.

This species, which is common on mud near shore at Flinders Island, is very close to *C. longistylis* Miers.

CILICAEOPSIS WHITELEGGEI Stebbing.

Cilicaea whiteleggei Stebb., Ceylon Pearl Oyster Fish., Suppl. Rep., No. xxiii., 1905, p. 39, pl. ix. (A), (B).

On sandy bottom in Owen Channel, 2 faths.

Mr. Baker considers that this form is referable to *Cilicaeopsis*.

Family IDOTEIDAE.

Only a single species of the family was secured, but this proves to be a form of considerable interest, for which it is necessary to erect a new genus.

Lyidotea, n. gen.

Body narrow, not very depressed. First antennae with very short flagellum, and flagellum of second antennae composed of a single long joint. Maxillipeds with palp wide and composed of three joints; basipodite and epipodite large. Peraeon with first six free segments normal, but with last segment fused with pleon. Coxae of peraeopods not expanded into plates, all fused with their respective thoracic segments, but on second to fourth segments marked off from pleura by a shallow furrow. First peraeopod shorter than others, subchelate and with propodus swollen. Pleon composed of a single segment and with indications of three fused segments near base.

Type, *L. nodata,* n. sp.

The generic characters are described from the female alone. The salient features are the structure of the antennae and the coalescence of the last thoracic segment with the abdomen.

Lyidotea nodata, n. sp.

Adult female. Integument soft. Body slender, widest at third peraeon segment, and narrowest at posterior end of sixth; seven times longer than greatest width. Cephalon wider than long, with anterior margin concave and antero-lateral angles slightly produced; dorsum elevated posteriorly to form a pair of high united tubercles; eyes dorso-lateral, of moderate size. First antennae reaching to end of second article of second antennae; basal joint expanded, as wide as long, longer than the second and as long as the third article; flagellum less than half as long as last peduncular joint, flattened and furnished with sensory appendages. Second antennae thick, less than half as long as body; first joint very short but visible in dorsal view; second two-thirds as long as third, which is a little shorter than fourth and equal in length to fifth; third, fourth and fifth joints dilated apically; flagellum slightly longer than fourth peduncular article, uniarticulate, and semi-cylindrical in shape, the outer face convex and the inner flattened; apex rounded (apparently with a minute terminal style). Outer lobe of first maxilla capped with ten spines, all but the innermost one being denticulate; slender inner lobe with two setose spines. Maxillipeds with basipodite shorter than epipodite; inner lobe reaching to middle of length of palp; first joint of palp short, the suture dividing it from second obscure; second joint a little longer than wide, and third suboval in shape. First four peraeon segments each with a pair of large dorsal elevations; fifth segment with a pair of obsolete tubercles, and sixth and seventh nearly smooth; first segment as long as, and barely wider than, cephalon; second, third and fourth segments subequal in length, each nearly twice as long as first, and wider than any of the others; sixth segment slightly shorter and narrower than fifth, which is shorter and narrower than fourth; seventh segment short, immovably fused with pleon, the suture most distinct laterally.

Peraeopods short and stout, the subchelate first much the shortest; the remaining six pairs are prehensile and subequal in length; coxae of second to fourth pairs barely visible in dorsal view. Lateral margins of pleon diverging posteriorly for three-fifths of length of pleon, then converging to the narrowly-rounded apex; pleon and last thoracic segment together as long as fourth, fifth and sixth peraeon

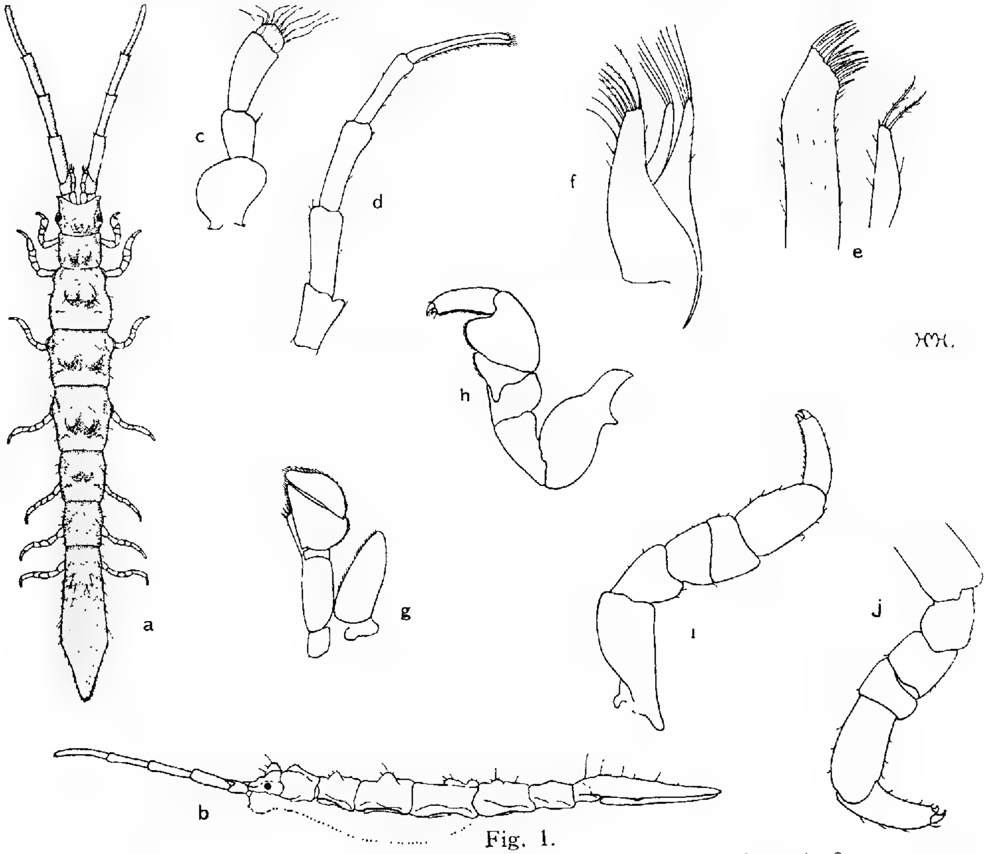


Fig. 1.

Lyidotea nodata, type female; a and b, dorsal and lateral views (x 8); c, first antenna (x 34); d, second antenna (x 13); e, first maxilla (x 100); f, second maxilla (x 100); g, maxilliped (x 34); h, i, and j, first, second and seventh peraeopods (x 34).

segments together. Uropods narrow, with posterior margin truncate, a little sinuate; endopod subtriangular, apically rounded.

Colour.—White, with sparse dots of pigment, producing a dingy grey appearance.

Length, 8 mm.

Loc.—North Queensland: Flinders Island, Princess Charlotte Bay.

Type.—Female, in South Austr. Mus., Reg. No. C. 1699.

The adult female described above and several smaller specimens were dredged in two fathoms. In the younger examples the dorsal elevations of the cephalon and peraeon are not so well developed as in the type, the pleon is shorter, etc.; also, the flagellum of the second antennae is slightly clavate, and not flattened on the inner face, a feature which may be due to the preservative. The middle of the dorsal portion of the articulation between the head and first peraeon segment is somewhat obscure, suggesting partial fusion here also, but laterally this segment is distinctly separated from the cephalon.

A NEW XANTHID CRAB FROM SOUTH AUSTRALIA.

By Mary J. Rathbun,
Associate in Zoology, United States National Museum.
(Communicated by H. M. Hale.)

[Read May 9, 1929.]

Plate IV.

The specimens here described were submitted to me by Mr. Herbert M. Hale, Curator of the South Australian Museum. They appear to be representatives of a new species.

Heteropanope vincentiana, n. sp.

Type-locality.—Port Willunga, Gulf St. Vincent, South Australia; Feb., 1895; W. J. Kimber, collector; female holotype, in South Australian Museum (Reg. No., C. 1849); male paratype in U.S. National Museum.

Measurements.—Female holotype, length of carapace 20, width of same 30·7, width of front 8·2, fronto-orbital width 15·7, chord of antero-lateral margin (to tip of last tooth) 10, length of major palm at its middle 15·6, greatest width of same 12·8, thickness 8, length of dactylus 13·6, approximate length of second ambulatory leg 40·5 mm.

Description.—Carapace (fig. 1) 1½ times as broad as long, antero-lateral margins thick, arcuate, shorter than the postero-lateral, cut into 4 blunt teeth, the first of which is distant from the orbit and is shallow and lobiform. No tooth at outer angle of orbit. Front deflexed, its margin invisible in dorsal view; its middle third is most advanced. Three shallow sinuses (fig. 2) divide the margin, forming a slight projection either side of the middle and a low, blunt, subrectangular tooth at each outer angle. A narrow, shallow furrow runs parallel and close to the margin. A rounded sinus separates the front from the obtuse inner angle of the orbit. Outer lower sinus of orbit shallow; inner half of lower margin arcuate.

Dorsal surface nearly flat in its posterior half; anterior half rounding downward. Regions scarcely indicated, except the narrow, anterior part of the mesogastric, from which a shallow median furrow is continued part way to the edge of the front. Anterior and antero-lateral regions coarsely and closely granulate; they are crossed by an irregular transverse furrow, a little behind the orbits. A transverse ridge runs inward from the last lateral tooth, extending less than half way to the median line. The granules become smaller, lower and gradually disappear on the postero-lateral regions. Smooth area punctate. Lower surface of carapace granulate.

The broad basal article of the antenna just touches with its inner angle the tip of the turned-down edge of the front; the outer angle of the same segment stands in the orbital hiatus. Ridges of endostome strong. The exognath of the outer maxilliped reaches just to the outer distal angle of the merus of the endognath (fig. 2); the merus has two deep, oblique curved furrows which enclose an oblong space; the impression on the ischium of the endognath is sharp (fig. 4) and is not continued at either end to the margin.

Chelipeds stout, very unequal. Merus of major cheliped nearly as broad as its greatest length; carpus heavy, its inner tuberculiform tooth a little behind the

middle of the margin; palm (fig. 3) high and thick, upper and lower margins convex, surface granulate-eroded in its upper half, punctate; fingers nearly horizontal; two large, low teeth on the basal three-fifth of the fixed finger; a large, backward-pointing, basal tooth on the dactylus; fingers brown in the preserved specimen, the colour ending in a scalloped edge at base of fixed finger. Minor cheliped similar, but fingers deflexed, deeply grooved, prehensile edges armed with alternating larger and two or three smaller teeth; fingers not gaping; colour not reaching palm. Legs long (fig. 1), the longer ones about twice as long as carapace, rather narrow, punctate and more or less rough; merus with a row of short, blunt spines above, lower surface rough with truncate granules; carpus, propodus and dactylus rough with sockets which are furnished with longish hairs; dactylus nearly straight, having a deep furrow on each side and terminating in a slender, bent, horny tip.

The abdomen of a male paratype (fig. 4) is rather broad; the third to sixth segments inclusive taken together have concave side margins; third, fourth and fifth segments of subequal length; sixth and seventh segments progressively longer.

This species may be recognised by its unusual width, coarse granulation and absence of hair from the carapace.

DESCRIPTION OF PLATE IV.

Heteropanope vincentiana.

Fig. 1. Dorsal view of ♀ holotype (nat. size).

Fig. 2. Front view of ♀ holotype (nat. size).

Fig. 3. Outer view of major chela of ♀ holotype (nat. size).

Fig. 4. Ventral view of ♂ paratype (x $1\frac{3}{4}$).

VARIATIONS OF HYDROGEN ION CONCENTRATION IN THE NEIGHBOURHOOD OF THE ESTUARY OF THE RIVER MURRAY.

By T. BRAILSFORD ROBERTSON
(Department of Biochemistry and General Physiology,
University of Adelaide, South Australia).

[Read May 9, 1929.]

Introduction; Statement of the Problem.

It has, for a long time past, been in my mind that much information of interest might result from a detailed investigation of the changes in composition, density, hydrogen ion concentration, and so forth, which the waters of the Murray River undergo as they debouch into the remarkable system of lakes which separate the river proper from the mouth through which these lakes discharge their surplus waters into the sea. It is not merely that much information of hydrographic interest might accrue from such a study, but the information thus obtained, coupled with a survey of the biological types inhabiting the different localities of this lake system, would probably reveal many facts of importance concerning the adaptations which various forms of life display to the fluctuations of their environment. Such fluctuations might be anticipated to be of three types, namely:—

(1) Tidal, (2) Seasonal, and (3) Geographical.

Those parts of the lake system which are most remote from the Murray mouth, such as the northern end of Lake Alexandrina, the eastern part of Lake Albert, and the south-eastern extremity of the Coorong, will be subject to less extensive tidal fluctuation of composition than the parts of the system which lie more adjacent to the mouth, but, on the other hand, while the waters of Lake Albert and the northern part of Lake Alexandrina are generally so fresh as to be potable, those of the Coorong, twenty miles from its opening into Lake Alexandrina, appear, to the sense of taste at all events, to be more saline than those of the sea. Between these two regions, both comparatively immune to tidal influence, lies an area subject to diurnal tidal fluctuations of very considerable magnitude. It is quite conceivable that this may interpose an effective barrier to the migration of certain forms, which are incapable of rapid short-period adaptation, from the one region of relatively constant composition to the other.[1] In this way some of the inhabitants of the Coorong may be barred off from mingling with those of Lake Albert. The question then arises whether any of the same species are to be found in these two localities, and, if so, whether individuals can migrate from the one locality to the other and, if not, whether the types inhabiting two such different environments are identical or present systematic differences related to the adaptations they have undergone and recognisable as such by taxonomists.

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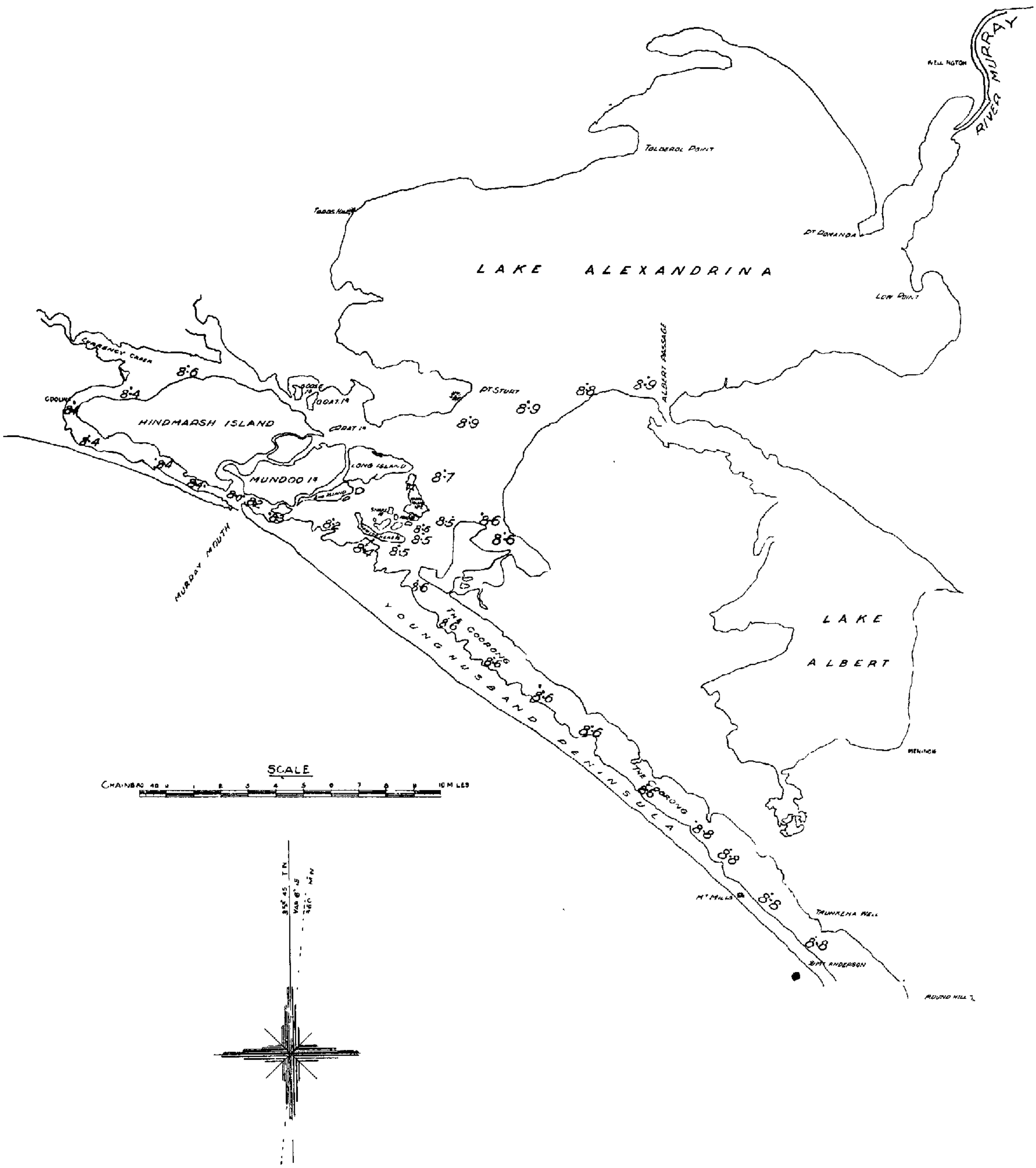
[1] When I say *relatively* constant I refer to the short-period diurnal variations due to tides, which exist, but are diminished as one recedes from the mouth. Seasonal variations, depending upon the volume of output from the river will occur, but their onset is usually less sudden than the changes due to tides, and the internal compensations or migrations necessary to fit the changed conditions would be possible to many forms which might not be able to accommodate themselves to extensive changes of salinity or hydrogen ion concentration occurring within a few hours.

For the benefit of possible readers abroad, who may not chance to be familiar with the geography of South Australia, I may perhaps mention that the Murray River opens out, about thirty miles from the sea, into Lake Alexandrina, the area of which is, roughly, some 200 square miles (*vide* accompanying map). Close to the mouth a cluster of islands breaks up the lake into numerous channels. On the eastern and south-eastern sides of the lake two large inlets occur. The one, Lake



Albert, of some 60 square miles in extent, communicates with Lake Alexandrina by a narrow mouth and spreads out into a wide, shallow expanse of water. The other, the Coorong, is a most remarkable sheet of water, not paralleled, to my knowledge, elsewhere. Varying from a mile to two miles in width, it runs in a south-easterly direction for about seventy miles, parallel to the shore, separated from the ocean by a narrow peninsula which is only from half a mile to two miles across. Only the upper third of the Coorong is shown in the accompanying map. It is, for the main part, very shallow, and boats drawing only two feet have to thread their way carefully at low tide through narrow channels which generally do not exceed four feet in depth. During the hot, dry summers which prevail in South Australia this sheet of water is subject to enormous losses, due to evaporation. From its mouth, where it joins the lake, to its lower extremity, where the effects of evaporation might be expected to attain their maximum, this long strip of shallow water should exhibit important differences of composition, density, reaction, etc., which, in turn, might be reflected in the characteristics of its plant and animal inhabitants.

The results which I have to report represent merely a preliminary survey of the variations in one single characteristic of the waters contained in this lake system, namely, the hydrogen ion concentration. They are presented here in the hope that the account of the extensive variations which I have found to occur within twenty miles of the mouth of the Murray will draw attention to the important problems presented by this area of water, which lies so conveniently close at hand, and excite others to carry forward such investigations in greater scope and detail. As the most important problems are actually the ecological ones (which I have not the opportunity or the qualifications to investigate), it is clear that what is needed to carry out an adequate inquiry is a committee, composed of chemists, qualified to investigate the properties and composition of the water samples; biologists, to determine the distribution of living types and estimate the modifications of type which are attributable to adaptation; someone familiar with the technique of surveying, to determine the precise positions of the points at which samples are taken and, since many matters of geological interest arise, such as the nature of the deposits formed from waters of different compositions, a geologist should be included upon the committee.

In explanation of the choice of hydrogen ion concentration as the particular physical characteristic measured in this preliminary study, I need only state that in European and American waters the distribution of fishes, and, presumably, of other marine forms, has been found to be profoundly affected by hydrogen ion concentration. To such an extent is this the case, that it appears probable that this factor is quite as important as density in affecting the lives of the organisms which inhabit the water. In regard to such questions I have no personal observations to report, but, according to the testimony of local fishermen, the Murray Cod is not found nearer the Murray mouth than Narrung, at the entrance of Lake Albert. Whether the bar to its further migration is constituted by the increasing salinity or decreasing alkalinity as the mouth is approached, cannot, of course, be stated.

Results.

The estimations of hydrogen ion concentration are expressed in terms of PH, following the now universal convention. The determinations were made with the aid of a Hellige Comparator, very kindly lent to me for this purpose by Mr. J. G. Wood, of the Department of Botany. The indicators employed were Cresol Red and Thymol Blue, the sensitive ranges of which cover the variation of PH values which were encountered in these determinations. The samples, wherever the depth of water permitted, were taken at a uniform depth of four

feet from the surface. This was accomplished by drawing out test tubes in a flame (applied to the upper extremity) into a narrow tube, then evacuating and sealing in the flame in such a way that the drawn out end fell over in the shape of a hook. Care must be taken not to employ too hot a flame, so that this bent, narrow end of the evacuated tube will remain hollow. These tubes were suspended by half-hitches in a thick line, provided with a heavy sinker, and a float so adjusted that it was four feet above the narrow end of the tube which pointed upwards. A thin line was attached to the hook-shaped narrow extremity of the evacuated tube and paid out loosely as the tube sank, until the float touched the water. The thin line was then sharply jerked, which resulted in breaking the narrow end of the tube, the water entering through the opening into the evacuated tube which, when drawn up, was full of water. The end was then further broken to permit the water to be poured out into the graduated tube in which it was mixed with the indicator solution. The samples were always taken from a stationary boat.

The results obtained under usual tidal conditions are shown in the accompanying map and may also be summarised as follows, the "starting point" in each case being a point just off the peninsular shore at the middle of Tauwitchere Channel, which is the narrow channel separating Tauwitchere Island from Younghusband's Peninsula. The distances given are in nautical miles

1. Starting point, across the Murray mouth and around the Western end of Hindmarsh Island:

Distance from Starting Point.	PH.
At starting point	8·4
1·5 miles towards mouth of Murray	8·2
3·5 miles towards mouth of Murray, just off mouth of Boundary Creek	8·3
4·5 miles, close to mouth, just at the corner of the south-west shore	8·2
5·1 miles, directly opposite the mouth off the shore of Mundoo Island	8·0
6·4 miles, being 1·3 miles from mouth towards Goolwa	8·4
8·0 miles	8·4
11·1 miles	8·4
13·3 miles, off Goolwa	8·4
15·4 miles, that is, 2·1 miles east from Goolwa, in the channel north of Hindmarsh Island ..	8·4
18·0 miles, that is, 4·7 miles east from Goolwa ..	8·6

2. Starting point, round the south-eastern extremity of Tauwitchere Island to Narrung, at the mouth of Lake Albert:

Distance from Starting Point.	PH.
2 miles, off Mud Island	8·6
4 miles in mid-channel, off the end of Long Island	8·7
6 miles, off the Point Sturt trig. station ..	8·9
8 miles, off the headland of Point McLeay ..	8·9
10 miles, just off Point McLeay Mission Station, in $3\frac{1}{2}$ feet of water	8·8
12 miles, just off the Albert Passage	8·9

3. Starting point, round south-eastern extremity of Tauwitchere Island to Loveday Bay:

Distance from Starting Point.	PH.
1 mile, off south-eastern end of Tauwitchere Island	8·5
2 miles, now heading direct for Loveday Bay ..	8·5
3 miles	8·5
4 miles, at entrance to Bay	8·6
5 miles, in Loveday Bay, off jetty on north shore, in $3\frac{1}{2}$ feet of water	8·6

4. From the opening of the Coorong to a point between Trunkena Well and Mount Anderson, 20 miles from the opening:

Distance from Opening.	PH.
0·5 miles	8·6
2·0 ,, ...	8·6
4·0 ,, ...	8·6
6·0 ,, ...	8·6
8·0 ,, ...	8·6
10·5 ,, ...	8·6
12·5 ,, ...	8·8
14·0 ,, ...	8·8
16·0 ,, ...	8·8
18·0 ,, ...	8·8

Discussion of the Results.

Analysing these results, with the aid of the accompanying map, it will be evident that, as we recede in every direction from the Murray mouth, the water becomes more alkaline. The distribution of the readings strongly suggests that the Murray River water is alkaline, having a PH of at least 8·9, and that the reaction of the sea-water at the mouth is much more nearly neutral, having a PH of 8·0 (neutrality = 7·2). To put it more concretely, in terms of actual hydroxyl ion concentrations, Murray River water appears to be about ten times as alkaline as the sea-water into which it is discharged.

Since the alkalinity increases more rapidly when we travel from the mouth in an easterly than in a westerly direction, the main flow of river-water, at the season at which these observations were made (at the end of summer, March 7 to 16, 1929), was round the eastern sides of the islands which are clustered around the mouth. This is also indicated by the fact that this channel is silting more rapidly than the channel around the western extremity of Hindmarsh Island, and the numerous sandbanks are changing position more frequently.

Although very saline, the water in the Coorong resembles river- rather than sea-water in its reaction. This may indicate that the Coorong represents virtually river-water, entrapped and rendered saline by evaporation. This explanation is upheld by the easterly course of the main flow of river-water, to which allusion has been made, which would bring the river-water past the mouth of the Coorong. An alternative explanation is possible, however, namely, that the high alkalinity of the Coorong water is due to the abundance of algae which inhabit it. It has been pointed out by Lipman (1) that algae increase the alkalinity of sea-water. When the anchor was dropped in Lake Alexandrina it came up coated with slime, but no algae. The anchor dropped in the Coorong, at a point about 8 miles from the mouth, came up completely coated with masses of algae.

The constant tendency for sandbanks and bars to form near the mouth of the Murray, which, in the past, has evidently given rise to some, if not all of the Islands clustered near the mouth, is commonly attributed to the deposition of

silt brought down by the river. It is not so generally recognised that part of this deposit may be derived from the sea-water itself, through the alkaline reaction communicated to it by admixture with the waters of the river. It has been shown by Lipman *(loc. cit.)* that the addition of sufficient alkali to sea-water, originally of $P_H = 8 \cdot 0$, to communicate to it an alkalinity corresponding to $P_H = 8 \cdot 8$ to $8 \cdot 9$, induces the formation of a precipitate consisting mainly of phosphates of calcium and aluminium, together with small proportions of iron and magnesium. In this way no less than sixty per cent. of the phosphoric acid in sea-water may be precipitated. It was observed, in fact, that the sea-water samples which were collected near the mouth, and originally clear, deposited a fine white precipitate on standing for about an hour in a test-tube, whereas samples collected in the body of the lake did not do so. Chemical examination of the silts near the mouth of the Murray should reveal to what extent this process is contributing to their formation.

The precise results obtained at any point will, of course, vary with the state of the tide. The values given represent those usually observed (for example, at the "starting point" in Tauwitchere Channel, where many observations were taken) or obtained at medium tide, neither high nor very low. The influence of tide was very clearly illustrated, however, when, on one occasion, at very low tide, on Monday, March 11, at 4.45 p.m., the P_H exactly opposite the mouth, off the point of Mundoo Island, had risen to $8 \cdot 4$ (that usually found, namely, in Tauwitchere Channel), while at 6 p.m., with the tide very low and still running out swiftly, the P_H found in Tauwitchere Channel was $8 \cdot 8$, the value, namely, which was found under medium tide conditions in the channel between Point Sturt and Point McLeay, and also 12·5 miles down the Coorong.

The values obtained in this investigation correspond very well with those found by Lipman *(loc. cit.)*, who reports 8·0 as the value commonly obtained for sea-water containing little or no algal growth, and states that values as high as 9·4 may be found in sea or fresh waters thickly inhabited by algae and exposed to the light to permit rapid photosynthesis. He suggests that the algal population may form a very important factor in determining the rate of deposition of phosphates of lime and aluminium from water, owing to the changes of P_H which they induce. If we accept this view, then my observations would suggest that such precipitation must be occurring at an exceptionally high rate in the waters of the Coorong, and should have led to notable changes in the composition of the dissolved mineral salts, whether these are mainly derived from the sea or from the river.

Acknowledgments.

In conclusion, I desire to thank the Lands and Survey Department for their very generous gift of the plans from which the map which accompanies this paper was constructed; to Mr. G. W. Bussell, for assistance in the construction of the map; to Mr. J. G. Wood, as stated above, for the loan of the Hellige Comparator used in obtaining the estimations of P_H values; to Mr. Hedley R. Marston, for preparing the apparatus employed for taking the samples of water; to Mr. J. D. O. Wilson, for the preparation of the glass tubes in which the samples were collected; to Mr. M. L. Mitchell, for the loan of the ship's log and angle sextant with the aid of which the positions were determined; and to my companions on the trip, Professor H. H. Woollard, Dr. P. Gorrie, and Messrs. G. Fowler and C. T. M. Roach, for valuable assistance in obtaining the samples for investigation.

Reference.

(1) Lipman, C. P., "The Chemical Composition of Sea-water," Carnegie Institution of Washington Publications, No. 391, 1929, pages 249 to 257.

A CENSUS OF THE MARINE ALGAE OF SOUTH AUSTRALIA.

Classified after De Toni, Sylloge Algarum.

By A. H. S. Lucas, M.A., B.Sc.
(Communicated by Professor J. B. Cleland, M.D.)

[Read June 13, 1929.]

This list includes all the South Australian Marine Algae, Green, Brown and Red, of which I can find records. It is doubtless far from giving a complete enumeration of all the Algae of these groups which occur on the coasts of South Australia, and a wide field for further discovery is open to collectors and investigators. The statement of what is known will be of use to succeeding workers.

Very little indeed is known of the marine flora of the Bight to the west of Cape Catastrophe. In the Melbourne Herbarium there are a few plants from Fowler's Bay, and one gathered by Tietkens at Denial Bay.

The Algae of Investigator Strait were collected by Miss Nellie Davey, and were recorded by Th. Reinbold, of Itzehoe, Denmark, in Hedwigia, Band xxxviii., 1899.

East of the strait more is known. Baron von Müeller (then Dr. Müeller), during his residence in Adelaide, collected on the Lefevre Peninsula, near the mouth of the River Torrens, in St. Vincent's Gulf, and some of his plants are preserved in the Melbourne Herbarium. I, myself, collected kelps at Brighton. Müeller's plants were determined by Dr. Sonder, of Hamburg.

Encounter Bay has been explored by: (1) Miss Jessie L. Hussey at Port Elliot, and her material made use of by J. G. Agardh, of Lund, Sweden; (2) by Professor J. B. Cleland and his family, continuously, at Victor Harbour and Middleton Bay; (3) by myself, in a brief stay at Victor Harbour. Dr. Cleland has entrusted me with his great mass of material.

The chief collection in the eastern bays was made by Dr. Engelhardt-Kingston. His plants were gathered with much zeal and knowledge in Lacepede and Guichen bays. They were recorded by Th. Reinbold in La Nuova Notarisia of De Toni in the years 1897, 1898. Miss Ellen Macklin, of the Adelaide University, collected considerably at Robe, and has placed her plants in my hands. Mrs. Dr. Wehl collected considerably at Macdonnell Bay; her material went to Sonder mostly, but a packet of them was sent after Sonder's death to the Sydney Herbarium.

The above, then, comprise the sources of the information on which this list has been compiled.

I have tried to make a beginning of a record of the geographical distribution along the coast. The records made are positive, but there are many blanks to be filled. Probably the great majority of the species extend over the whole coastline. The numerals indicate the regions, as follows:—

1. Investigator Strait (Miss Davey).
2. Encounter Bay (Miss Hussey, Dr. Cleland).
3. The Eastern Bays (Dr. Engelhardt, Miss Macklin, Mrs. Wehl).

Fragmentary—

4. Great Australian Bight.
5. Spencer Gulf.
6. Gulf St. Vincent.

CHLOROPHYCEAE (Kuetz. *ex parte*) Wittrock.

Order CONFERVOIDEAE (Ag.) Falk.

Family ULVACEAE (Lamour.) Rabenh.

ULVA Linnaeus.

U. lactuca L. 1, 2, 3.

ENTEROMORPHA Link.

E. compressa (L.) Grev. 3.
E. crinita (Roth.) J. Ag. 3.
E. clathrata (Roth.) J. Ag. 3.

Family ULOTRICHIACEAE (Kuetz.) Borzi, em.

ENDODERMA Lagerheim.

E. viride (Reinke). 3.

Family CLADOPHORACEAE (Hassall) Wittrock.

CHAETOMORPHA Kuetz.

C. darwinii (H. & H.) Kuetz. 3.
C. coliformis Mont. 2.

CLADOPHORA Kuetz.

C. valonioides Sond. 1.
C. nitidula Sond. 1.
C. daveyana Reinb. 1.
C. conformis Reinb. 3.

DICTYOSPHAERIA Decaisne.

D. sericea Harv. 1, 2.

APJOHNIA Harvey.

A. laetevirens Harv. 1, 2, 3.

Order SIPHONEAE Grev., em.

Family BRYOPSIDACEAE (Bory) Thur.

BRYOPSIS Lamour.

B. plumosa (Huds.) Ag. 1, 3.
B. vestita J. Ag. 3.

Family CAULERPACEAE Reichenbach.

CAULERPA Lamour.

C. scalpelliformis (R. Br.) Ag. 3.
C. plumaris Forskaal. 3.
C. longifolia Ag. 2.
C. harveyi F. v. M. 3.
C. abies-marina J. Ag. 1. (Reinbold identifies with *C. cliftoni* Harv.)
C. obscura Sond. 1845.
= *C. sonderi* F. v. M. 1852. 1, 3.
C. brownii Endl. 1, 2, 3.
C. flexilis Lamour. 3.
C. hypnoides (R. Br.) Ag. 2, 3.
C. vesiculifera Harv. 3.
C. cactoides (Turn.) Ag. 1, 2, 3.

CODIUM Stackhouse.

C. bursa (L.) Ag. 2.
C. mammillosum Harv. 2.
C. muelleri Kuetz. 1, 2, 3.

PHAEOPHYCEAE (Thur.) Kjellm., 1891 (Engler and Prantl.).
= FUCOIDEAE Ag., 1817 (De Toni).

Order CYCLOSPORINAE Areschoug.

Family SARGASSACEAE (Dcne.) Kuetz.

SEIROCOCCUS Grev.

S. axillaris (R. Br.) Grev. 1, 2, 3.

SCYTOTHALIA Grev.

S. dorycarpa (Turn.) Grev. 2, 3.

CYSTOPHYLLUM J. Ag.

C. muricatum (Turn.) J. Ag. 2.

CARPOGLOSSUM Kuetz.

C. confluens (R. Br.) Kuetz. 2, 3.

SARGASSUM Ag.

S. sonderi J. Ag. 1, 3.
S. varians Sond. 2, 3.
S. decipiens (R. Br.) J. Ag. 1, 3.
S. verruculosum (Mert.) Ag. 2, 3.
S. cristatum J. Ag. 1, 3.
S. spinuligerum Sond. 1, 3.

SCABERIA Grev.

S. agardhii Grev. 2.
S. rugulosa J. Ag. South Australia (Melb. Herbm.).

CYSTOPHORA J. Ag.

C. uvifera (Ag.) J. Ag. 1, 2, 3.
C. cephalornithos (Lab.) J. Ag. 2, 3. K.I.
C. platylobium (Mert.) J. Ag. 2, 3.
C. racemosa Harv. 1, 2, 3.
C. retorta (Mert.) J. Ag. 2.
C. retroflexa (Lab.) J. Ag. 2.
C. dumosa (Grev.) J. Ag. 1.
C. botryocystis Sond. 1, 2.
C. Grevillei (Ag.) J. Ag. 1.
C. spartioides (Turn.) J. Ag. 1, 2, 3.
C. monilifera J. Ag. 1, 3.
C. polycystidea Aresch. 1, 2. K.I.

Family FUCACEAE (Lamour.) Kjellm.

HORMOSIRA Endlicher.

H. banksii (Turn.) Dcne. 1, 2.
H. gracilis Kuetz. 1, 2. K.I.

Order TETRASPORINAE De Toni.

Family DICTYOTACEAE (Lamour.) Zan.

GYMNOSORUS J. Ag.

G. nigrescens (Sond.) J. Ag. 1.

ZONARIA (Draparn.) J. Ag.

Z. diesingiana J. Ag. 3.
Z. crenata J. Ag. 1, 3.
Z. turneriana J. Ag. 1, 3.

HOMOEOSTRICHUS J. Ag.

H. stuposus (R. Br.) J. Ag. 3.
H. canaliculatus J. Ag. 3.
H. spiralis J. Ag. 2.

CHLANIDOTE J. Ag.

Ch. microphylla (Harv.) J. Ag. 3.

HALISERIS Targ. Tozz.

H. muelleri Sond. 1, 2, 3.
H. acrostichoides J. Ag. 3.

DICTYOTA Lamour.

D. latifolia J. Ag. 1.
D. ocellata J. Ag. 1.
D. radicans Harv. 1, 3.

PACHYDICTYON J. Ag.

P. furcellatum (Harv.) J. Ag. 3, 6.

DILOPHUS J. Ag.

D. marginatus J. Ag. 2.
D. fastigiatus (Sond.) J. Ag. 3.

LOBOSPIRA Aresch.

L. bicuspidata Aresch. 2, 3.

Order PHAEOZOOSPORINAE Thuret.

Family LAMINARIACEAE (Bory) Rostaf.

ECKLONIA Hornem.

E. radiata (Turn.) J. Ag. 2.

MACROCYSTIS Ag.

M. pyrifera (Turn.) Ag. 3.

Family SPOROCHNACEAE (Reichb.) Dcne.

PERITHALIA J. Ag.

P. inermis (R. Br.) J. Ag. 2, 3.

ENCYOTHALIA Harv.

E. cliftoni Harv. 1, 2, 3.

SPOROCHNUS Ag.

S. comosus Ag. 3.
S. gracilis J. Ag. 3. Slenderer form of *S. comosus,* with longer pedicals. Not recognised by De Toni.
S. radiciformis (R. Br.) Ag. 3.
S. scoparius Harv. 1.

Family CHORDARIACEAE (Ag.) Zan.

CORYNOPHLOEA Kuetz.
C. zostericola Harv. 2.

LEATHESIA Gray.
L. difformis (L.) Aresch. 2.

There must be several other representatives of the Family on the South Australian coasts, but they do not seem to have been noted.

Family ENCOELIACEAE (Kuetz.) Kjellm.

PUNCTARIA Grev.
P. latifolia Grev. 3.

SCYTOSIPHON Ag.
S. lomentarius (Lyngb.) J. Ag. 3.

PHYLLITIS.

COLPOMENIA Derb. and Sol.
C. sinuosa (Roth.) Derb. and Sol. 3.

HYDROCLATHRUS Bory.
H. cancellatus Bory. 2, 5.

SPHACELARIA Lyngb.
S. furcigera Kuetz. 3.

CLADOSTEPHUS Ag.
S. spongiosus (Lightf.) Ag. 2.

STYPOCAULON Kuetz.
S. paniculatum (Suhr.) Kuetz. 3.
S. funiculare (Mont.) Kuetz. 3.

RHODOPHYCEAE Ruprecht, 1855 (Engler and Prantl.).

FLORIDEAE Lamouroux, 1813 (De Toni).

EU-FLORIDEAE De Toni.

Order NEMALIONINAE Schmitz.

Family GELIDIACEAE (Kuetz.) Schmitz.

WRANGELIA Ag.
W. myriophylloides Harv. 1, 3.
W. velutina Harv. 2, 3.
W. verticillata Harv. 3.
W. crassa H. and H. 3.
W. wattsii Harv. 3.
W. clavigera Harv. 3.
? *W. princeps* Harv. 1. (Reinbold uncertain.)

GELIDIUM Lamour.
G. australe J. Ag. 1, 2, 3.
G. glandulaefolium H. and H. 3.

PTEROCLADIA J. Ag.
P. lucida (R. Br.) J. Ag. 1, 2, 3.

Order GIGARTININAE Schmitz.

Family GIGARTINACEAE Schmitz.

GIGARTINA Stackhouse.
G. flabellata J. Ag. 3.
G. disticha Sond. 1, 3.
G. pinnata J. Ag. 3.
G. wehliae Sond. 3.

STENOGRAMMA Harv.
S. interruptum (Ag.) Mont. 6.
S. leptophyllum J. Ag. 2, 6.

MYCHODEA Harv.
M. membranacea Harv. 3.
M. carnosa Harv. 3.
M. hamata Harv. 2, 3.
M. compressa Harv. 3.
M. nigrescens Harv. 3.
M. disticha Harv. 1, 3.
M. foliosa (Harv.) J. Ag. 3.
M. linearis J. Ag. ms. 4. Fowler's Bay.

DICRANEMA Sonder.
D. grevillei Sond. 1, 2, 3.

CALLOPHYLLIS Kuetz.
C. harveyana J. Ag. 3.
C. marginifera J. Ag. 3.
C. lambertii (Turn.) Grev. 1, 2, 3.
C. coccinea Harv. 1, 3.
C. carnea J. Ag. 2, 3.
C. australis Sond. 3.

POLYCOELIA J. Ag.
P. laciniata J. Ag. 3.
P. chondroides J. Ag. 3.

CALLYMENIA J. Ag.
C. tasmanica Harv. 3.

MEREDITHIA J. Ag.
M. polycoelioides J. Ag. 3, 6.

GELINARIA Sond.
G. harveyana J. Ag. 1, 3.

Family RHODOPHYLLIDACEAE Schmitz.

GLOIOPHYLLIS J. Ag.

G. barkeriae (Harv.) J. Ag. 3.
G. engelhardtii Reinb. 3.

RHODOPHYLLIS Kuetzing.

R. volans Harv. 3.
R. blepharicarpa Harv. 3.
R. ramentacea (Ag.) J. Ag. 3.
R. membranacea Harv. 3.
R. multipartita Harv. 3.
R. brookeana J. Ag. 3.
R. tenuifolia (Harv.) J. Ag. 1, 3.
R. goodwiniae J. Ag. 3.

ERYTHROCLONIUM Sond.

E. angustatum Sond. 3.
E. sonderi Harv. 3.
E. muelleri Sond. 1, 3.

RHABDONIA Harv.

R. nigrescens Harv. 3.
R. coccinea Harv. 1, 2.
R. dendroides Harv. 3.
R. verticillata Harv. 1, 2, 3.
R. clavigera J. Ag. 3.
R. robusta (Grev.) J. Ag. 1.

ARESCHOUGIA Harv.

A. congesta (Turn.) J. Ag. 3.
= *A. gracilarioides* Harv.
A. laurencia (H. and H.) Harv. 1, 2, 3.
A. ligulata Harv. 3.

THYSANOCLADIA *Endl.*

T. harveyana J. Ag. 3.
T. oppositifolia (Ag.) J. Ag. 1, 3.

Order RHODYMENINAE Schmitz.

Family SPHAEROCOCCACEAE (Dum.) Schmitz.

PHACELOCARPUS Endl. and Dies.

P. complanatus Harv. 3.
P. alatus Harv. 3.
P. labillardieri (Mert.) J. Ag. 2, 3.
P. sessilis Harv. 3.

STENOCLADIA J. Ag.

S. ramulosa J. Ag. 3.
= *Areschougia dumosa* Harv.

NIZYMENIA Sond.

N. australis Sond. 3.

MELANTHALIA.

M. concinna (R. Br. ?) J. Ag. 3.
M. obtusata (Lab.) J. Ag. 3.

CURDIEA Harv.

C. laciniata Harv. 2, 3.

GRACILARIA Grev.

G. harveyana J. Ag. 3.

TYLOTUS J. Ag.

T. obtusatus (Sond.) J. Ag. 3.

HYPNEA Lamour.

H. musciformis (Wulf.) Lamour. 3.
H. episcopalis H. and H. 1, 2, 3.
H. seticulosa J. Ag. 1, 3.
H. hamulosa (Turn.) Mont. 1.
Determined by Reinbold. A Red Sea and Cape of Good Hope species. Not recorded for Australia by De Toni.

RHODODACTYLIS J. Ag.

R. bulbosa (Harv.) J. Ag. 3.

Family RHODYMENIACEAE (Naeg.) J. Ag.

GLOIODERMA J. Ag. = HOREA Harv.

G. australe J. Ag. 3.
= *Horea polycarpa* Harv.
G. halymenioides (Harv.) J. Ag. 1.
G. tasmanicum Zan. 3.
= *Horea speciosa* Harv.

STICTOSPORUM Harv.

S. nitophylloides (Harv.) J. Ag. 3.

RHODYMENIA Grev.

R. foliifera Harv. 3.

SEBDENIA Berth.

S. kallymenioides (Harv.) J. Ag.

HYMENOCLADIA J. Ag.

H. dactytoides (Sond.) J. Ag. 4 (Fowler's Bay.)
H. ceratoclada J. Ag. 2.
H. usnea (R. Br.) J. Ag. 1, 2, 3, 4 (Fowler's Bay), 6 (Adelaide).
H. divaricata (R. Br.) Harv. 3, 6 (Hallett's Cove).
H. polymorpha (Harv.) J. Ag. 2, 3, 4 (Fowler's Bay).

CHRYSYMENIA J. Ag.
C. brownii (Harv.) J. Ag. 2, 3.

CHAMPIA Desv.
C. parvula (Ag.) J. Ag. 3.
C. affinis (H. and H.) J. Ag. 1, 3.
C. obsoleta Harv. 3.
C. tasmanica Harv. 1, 3.

CHYLOCLADIA Grev.
C. fruticulosa Reinb. 1.

ERYTHROCOLON J. Ag.
E. muelleri (Sond.) De Toni. 3, 6 (Lefebre).

BINDERA Harv.
B. splanchnoides Harv. 1.

PLOCAMIUM Lamour.
P. leptophyllum Kuetz. 1, 3.
P. flexuosum H. and H. 3.
P. preissianum Sond. 2, 3.
P. angustum (J. Ag.) H. and H. 1, 2, 3.
P. costatum (J. Ag.) H. and H. 1, 3.
P. nidificum (Harv.) J. Ag. 1, 3.
P. mertensii (Grev.) Harv. 2, 3.
P. procerum (J. Ag.) Harv. 3.
P. dilatatum J. Ag. 3.

Family DELESSERIACEAE (Naeg.) Schmitz.

NITOPHYLLUM Grev.
N. gunnianum Harv. 3.
N. erosum Harv. 3.
N. pristoideum Harv. 2, 3.
N. minus (Sond.) Harv. 3.
N. affine Harv. 2, 3.
N. parvifolium J. Ag. 3.
N. polyanthum J. Ag. 2, 6.
N. validum J. Ag. 2.
N. curdieanum Harv. 1, 2, 3.

PACHYGLOSSUM J. Ag.
P. husseyanum J. Ag. 3.
P. engelhardtii J. Ag. 3.

HYPOGLOSSUM Kuetz.
H. denticulatum J. Ag. 3.
H. lacepedeanum Reinb. 3 (*Delesseria*, 1 Reinb.).

CHAUVINIA Harv.
C. coriifolia Harv. 3.

PHITYMOPHORA J. Ag.
P. imbricata J. Ag. 3.

APOGLOSSUM J. Ag.
A. tasmanicum (F. v. M.) J. Ag.

HEMINEURA Harv.
H. frondosa Harv. 3.

SARCOMENIA Sonder.
S. mutabilis (Harv.) J. Ag. 1.
S. tenera (Harv.) J. Ag. 1.

SONDERELLA Schmitz.
S. linearis (Harv.) Schmitz. 3.

Family BONNEMAISONIACEAE (Trev.) Schmitz.

PTILONIA J. Ag.
P. australasica Harv. 3.

DELISEA Lamour.
D. hypneoides Harv. 1, 3.
D. pulchra (Grev.) Mont. 3.

BONNEMAISONIA Ag.
B. asparagoides (Wordw.) Ag., var. *hypneoides* Reinb. 1.

ASPARAGOPSIS Mont.
A. armata Harv. 1, 3.

Family RHODOMELACEAE (Reich.) Harv.
Subfamily LAURENCIEAE (Harv.) Zan.

LAURENCIA Lamour.
L. filiformis (Ag.) Mont. 3.
L. forsteri (Mert.) Grev. 1, 3.
L. casuarina J. Ag. 3.
L. obtusa (Huds.) Lamour. 1.
L. tasmanica H. and H. 1.
L. elata (Ag.) Harv. 1.

CORYNECLADIA J. Ag.
C. umbellata J. Ag. 3.

JANCZEWSKIA Solms-Laubach.
J. tasmanica Falk. 1.

Subfamily CHONDRIEAE (Kuetz.) Schmitz.

CHONDRIA.
C. tenuissima.
f. subtilis Kuetz. 1.
C. succulenta (J. Ag.) Falk. 3.

MASCHALOSTROMA Schmitz.
M. scoparium Schmitz. 3.
= *M. fastigiatum* Falk.

CLADURUS Falk.
C. elatus (Sond.) Falk. 3.

COELOCLONIUM J. Ag.
C. umbellula (Harv.) Reinb. 1, 3.
C. verticillatum (Harv.) J. Ag. 1, 3.
C. opuntioides (Harv.) J. Ag. 1, 3.
C. incrassatum J. Ag. 3.

Subfamily POLYSIPHONIEAE (Kuetz.) Schmitz and Falk.

POLYSIPHONIA Grev.

OLIGOSIPHONIA J. Ag. (4 siphons).
P. mollis H. and H. 3.
P. crassiuscula Harv. 3.
P. ferulacea Suhr. 3.
P. blandi Harv. 3.
P. hookeri Harv. 3.
P. hystrix H. and H. 2, 3.
P. mallardiae Harv. 3.
P. Daveyae Reinb. 1.

POLYSIPHONIA J. Ag.
(More than 4 siphons).
P. cancellata Harv. 2, 3.
P. atricapilla J. Ag. 3.

CHIRACANTHA Falk.
C. valida (J. Ag.) Falk. 3.

Subfamily PTEROSIPHONIEAE Falk.

POLLEXFENIA Harv.
P. pedicellata Harv. 1.
P. lobata (Lamour ?) Falk. 3.

DICTYMENIA Grev.
D. harveyana Sond. 2, 3.
D. tridens (Mert.) Grev. 3.
D. angusta J. Ag. 3.

Subfamily LOPHOTHALIEAE Schmitz and Falk.

BRONGNIARTELLA Bory.
B. australis (Ag.) Schmitz. 1.
B. sarcocaulon (Harv.) Schmitz. 3.

LOPHOTHALIA Kuetz.
L. verticillata (Harv.) Kuetz. 3.

DOXODASYA Schmitz.
D. lanuginosa (J. Ag.) Falk. 2, 3.

Subfamily POLYZONIEAE Schmitz.

EUZONIELLA Falk.
E. incisa (J. Ag.) Falk. 1.

CLIFTONAEA Harv.
C. semipennata (Lamour.) J. Ag.

Subfamily HERPOSIPHONIEAE Schmitz and Falk.

HERPOSIPHONIA Naegeli.
H. rostrata (Sond.) Falk. 1, 3.
H. versicolor (H. and H.) Falk. 1, 3.

Subfamily RYTIPHLOEEAE (Dcne) Kuetz.

PROTOKUETZINGIA Falk.
P. australasica (Mont.) Falk. 1.

AMANSIA Lamour.
A. pinnatifida Harv. 2, 3.

VIDALIA Lamour.
V. spiralis Lamour. 1.

OSMUNDARIA Lamour.
O. prolifera Lamour. 1, 2, 3.

LENORMANDIA Sond.
L. muelleri Sond. 2, 3.
L. latifolia Harv. 2.

Subfamily HETEROCLADIEAE Dcne.

TRIGENEA Sond.
T. umbellata J. Ag. 2, 3.

Subfamily DASYEAE (Kuetz.) Schmitz and Falk.

THURETIA Dcne.

T. quercifolia Dcne. 1, 3.

DASYA Ag.

D. hapalathrix Harv. 3.
D. frutescens Harv. (?). 1.
D. cliftoni Harv. 1.
D. elongata Sond. 1, 3.
D. naccarioides Harv. 3.
D. capillaris H. and H. 3.
D. villosa Harv. 1, 2, 3.
D. velutina J. Ag. 3.

HETEROSIPHONIA Montagne.

H. wrangelioides (Harv.) Falk. 1.
H. gunniana (Harv.) Falk. 1, 2, 3.
H. guichensis (Reinb.) De Toni. 3.
H. curdieana (Harv.) Falk. 1, 3.
H. muelleri (Sond.) De Toni. 3.

HALODICTYON Zan.

H. robustum Harv. 3.
H. velatum Reinb. 3.

Family CERAMIACEAE (Bonnem.) Naeg.

Subfamily GRIFFITHSIEAE Schmitz.

GRIFFITHSIA Ag.

G. gunniana J. Ag. 3.
G. flabelliformis Harv. 3.
G. monile Harv. 1, 3.

Subfamily MONOSPOREAE Schmitz.

BORNETIA Thuret.

B. meredithiana J. Ag. 3.

MONOSPORA Solier.

M. griffithsioides (Sond.) De Toni. 3.
M. elongata (Harv.) De Toni. 3.

Subfamily CALLITHAMNIEAE (Kuetz.) Schmitz.

CALLITHAMNION Lyngb.

C. multifidum Harv. 3.
C. laricinum Harv. 1, 3.
C. spinescens Kuetz. 3.
C. pulchellum Harv. 1, 3.

Subfamily SPONGOCLONIEAE Schmitz.

SPONGOCLONIUM Sond.

S. brounianum (Harv.) J. Ag. 1.

HALOPLEGMA Mont.

H. preissii Sond. 1, 2, 3.

Subfamily WARRENIEAE Schmitz.

WARRENIA (Harv. ms.) Kuetz.

W. comosa Harv. 3.

Subfamily PTILOTEAE Cramer.

EUPTILOTA Kuetz.

E. articulata (J. Ag.) Schmitz. 3.
E. coralloidea (J. Ag.) Kuetz. 2, 3.

Subfamily DASYPHILEAE Schmitz.

DASYPHILA Sond.

D. preissii Sond. 2, 3.

Subfamily CROUANIEAE Schmitz.

BALLIA Harv.

B. callitricha (Ag.) Mont. 1, 2, 3.
B. robertiana Harv. 3.
B. mariana Harv. 3.
B. hamulosa J. Ag. 3

ANTITHAMNION Naeg.

A. horizontale (Harv.) J. Ag. 3.
A. nodiferum J. Ag. 3.
A. mucronatum (J. Ag.) De Toni. 1.

CROUANIA J. Ag.

Species (Reinbold).

LASIOTHALIA Harv.

L. formosa (Harv.) De Toni. 1.

PTILOCLADIA Sond.

P. pulchra Sond. 3.

Subfamily SPYRIDEAE J. Ag.

SPYRIDIA Harv.

S. biannulata J. Ag. 1, 3.
S. breviarticulata J. Ag. 1, 3.
S. opposita Harv. 2, 3, 6.
S. squalida J. Ag. 2, 3.

Subfamily THAMNOCARPEAE (Incertae sedis).

THAMNOCARPUS Harv.

T. harveyanus J. Ag. 3.
T. glomeruliferus J. Ag. 3.

Subfamily CERAMIEAE (Dumort.) Schmitz.

CERAMIUM Wiggers.

C. puberulum Sond. 1, 3, 6 (Lefebre).
C. subcartilagineum J. Ag. 2, 3.
C. nobile, J. Ag. 3.
C. gracillimum Griff. and Harv. 3.

Order CRYPTONEMINAE Schmitz.

Family GRATELOUPIACEAE Schmitz.

HALYMENIA C. Ag.

H. harveyana J. Ag. 3.

PACHYMENIA J. Ag.

P. stipitata J. Ag. 2, 3, 6.

PRIONITIS J. Ag.

P. microcarpa (Ag.) J. Ag. 2.

POLYOPES J. Ag.

P. constrictus (Turn.) J. Ag. 2.

CARPOPELTIS Schmitz.

C. phyllophora (H. and H.) Schmitz. 2, 3, 6.
C. elata (Harv.) Schmitz. 4 (Denial Bay).

CRYPTONEMIA J. Ag.

C. undulata Sond. 3, 6.

THAMNOCLONIUM Kuetz.

T. claviferum J. Ag. 3, 6.
T. dichotomum J. Ag. 6 (Lefebre).
T. proliferum Sond. 6.

Family RHODOPELTIDEAE, Fam. Nov.

RHODOPELTIS Harv.

R. australis Harv. 2, 3.

Family CORALLINACEAE (Gray) Harv.

LITHOTHAMNION Philippi.

L. lichenoides (Ell. and Sol.) Heydrich. 3.

Foslie places here *Melobesia Patena* H. and H., usually present on *Ballia callitricha*.

MELOBESIA Lamour.

M. farinosa Lamour. 1.

DERMALITHON Foslie.

D. pustulatum (Lamour.) Foslie. 1, 3.

MASTOPHORA Dcne.

M. lamourouxii Dcne. 1, 2, 3.
M. canaliculata Harv. 3.

LITHOPHYLLUM Philippi.

L. amplexifrons (Harv.) Heydr. 3.

AMPHIROA Lamour.

A. ephedraea (Lamck.) Dcne. Kangaroo Island.

METAGONIOLITHON Weber de Bosse.

M. charoides (Lamour.) Weber de Bosse. 2.
M. stelligerum (Lamck.) Weber de Bosse. 3.

JANIA Lamour.

J. micrarthrodia Lamour. 1.
J. rubens Lamour. 3.

CORALLINA (Tournefort) Lamour.

C. Cuvieri Lamour.

Chorophyceae	29
Phaeophyceae	61
Rhodophyceae	250
Total	340

NOTES ON THE FAUNA OF DIRK HARTOG ISLAND, WESTERN AUSTRALIA.

No. 1.—INTRODUCTION.

By EDWIN ASHBY, F.L.S., M.B.O.U., etc.

[Read June 13, 1929.]

Dirk Hartog Island is the most westerly land in the continent of Australia, is 50 miles in length by a width of 4 to 8 miles, and forms with Dorre Island and Bernier Island to the north, the western barrier of Shark Bay, sheltering its waters from the heavy western swell of the Indian Ocean.

On October 25, 1616, Dirk Hartog, a Dutch navigator, landed on the northern end of the island at Cape Inscription, where he nailed to a post a plate upon which was inscribed his name, the date of his landing, and the name of his vessel. In 1697 Willem de Vlaming visited the same spot, took down Hartog's plate, replacing it with his own, and ultimately depositing the original in the State museum at Amsterdam, where it is now preserved.

On August 1, 1699, the British navigator, William Dampier, anchored in Shark Bay and spent eight days searching for water, and from there took home to Europe a few botanical specimens, one of which has been named after him, *Diplolaena dampieri*. But it is to the French expedition, of which the ship "Uranie," under the Captain Mons. de Freycinet, which anchored in Shark Bay in September, 1818, that we are indebted for the first investigation of the fauna of Dirk Hartog Island. One of the surgeons of the expedition, Mons. Quoy, landed on the Island and, as a result of his collecting, the Black and White Wren that is endemic to Dirk Hartog Island and Barrow Island was described. A century passed by before that island was again visited by a competent ornithologist. In 1916 Mr. Thomas Carter spent two or three months collecting there, partly in the early winter and again in late spring; he re-discovered the Black and White Wren, whose very existence had been doubted for almost a hundred years, and he also described several very interesting subspecies that are endemic to the island. Then in 1918 and 1920, Mr. F. Lawson Whitlock paid two fairly lengthy visits to the island, adding thereby to our knowledge of its avifauna.

On the conchological side, in 1905, Drs. Michaelsen and Hartmeyer, in the interests of the Hamburg South-West Australian Expedition, did a good deal of collecting in Shark Bay, and in 1911 Dr. J. Thiele described the chitons collected by them; of the seven then described as new, several were from Shark Bay. The types of these are in the Berlin Museum, and hitherto only one of the seven has been represented in any Australian collection.

The two main objects of the writer's visit was to study and collect the specialized avifauna of Dirk Hartog Island and to collect examples for Australian collections of some of Thiele's new species of chitons. In both of these directions the expedition was largely successful. My colleague, Dr. A. Chenery, and myself had planned to give a week or ten days to the island, but owing to the unfortunate stranding of the steamer that calls in at Shark Bay, my time was reduced to four clear days, September 24 to 27, 1927. Dr. Chenery was able to stay a few more days, but I had to catch the motor mail at Carnarvon to keep another appointment. During our stay we were generously entertained by Mrs. and Major Chenery who are part owners of the Dirk Hartog sheep station, and I gladly take this opportunity of expressing my thanks, and also acknowledge our indebtedness to the Chief Inspector of Fisheries (Mr. Aldrich) of Perth, and Mr. Walter Edwards, the Fisheries Inspector stationed at Shark Bay, who both

showed us many kindnesses. The rocks are limestone or coral, both unsuited to *Polyplacophora*, and the chiton fauna was numerically very poor. Examples of some of the species collected were sent to Dr. J. Thiele, of Berlin, to compare with his types, and extracts of his replies are quoted herein.

The rainfall of the island is about 12 inches. Trees are quite absent, but extensive areas are covered with low "scrub," some of the larger bushes reach a height of 15 feet; representatives of the Leguminosae, Myrtaceae, Proteaceae, Malvaceae and other families were noticed in this scrub, and many of them were very showy when in flower, but the genus *Eucalyptus* was represented by only a few meagre patches of dwarf mallee-like forms. There was a large variety of herbaceous and annual plants, which together with many of the bushes are found to be excellent sheep feed.

Thomas Carter's paper, "The Birds of Dirk Hartog Island: 'The Ibis' " (vol. v., No. 4, pp. 564-611, 1917), and F. Lawson Whitlock's paper, "Notes on Dirk Hartog Island: 'The Emu' " (vol. xx., pp. 168-189, Jan., 1921), both furnish maps and are exceedingly interesting and informative. The notes under the heading "Aves" are the combined observations of Dr. A. Chenery and the writer. The mollusca collected, other than chitons, were handed over to the South Australian Museum, and the following coleoptera also were handed over to the same museum and identified by Arthur M. Lea.

COLEOPTERA.

Scarabaeidae.

Haplonycha crassiventris Blanch.

Bolboceras insigne Lea.

Two examples of each of these came to light at the homestead, Dirk Hartog Island. Mr. Lea states that both these species are very desirable ones, only known by very few examples. Of the former only two examples have hitherto been known, the type being in the Paris Museum and the other in the Blackburn Collection, labelled as having come from Lake Austin, Western Australia.

Chrysomelidae.

Paropsis hemisphaerica Chp.

Paropsis niobe Blackburn.

MOLLUSCA.

A number of shells were collected by the writer, and it was intended to publish the record as a separate paper, but they have unfortunately been absorbed into the Museum Collection, with the exception of a member of the Fissurellidae belonging to the genus *Eligidion*, this is being described by Mr. B. C. Cotton, Assistant Conchologist of the South Australian Museum, to which Museum all the coleoptera and mollusca collected (except chitons) have been presented by the writer.

Indo-Australian Faunal Region.

Ashby, in "The Regional Distribution of Australian Chitons" (Report Aust. Assn. Adv. Sci., vol. xvii, pp 366-393, 1924), proposed a new Faunal Region, based on the influence of a warm current that is shown by Haligan to come in from the Indian Ocean and impinge on the coast of Australia at Shark Bay (of which bay Dirk Hartog Island forms part of the western rampart), this current then flows down the west coast, turning at Cape Leeuwin in an easterly direction and flowing along the southern coast of the Australian Continent over the cold and heavier western or antarctic current. Haligan supplies data to show that the

temperature of the surface water is raised appreciably by this current as far as Cape Northumberland on the eastern border of the State of South Australia. The limited evidence that it was possible to obtain during this expedition, certainly, from the point of view of the *Polyplacophora,* supports the acceptance of the proposed Indo-Australian Faunal Region.

The two open ocean species of chiton, both common and endemic to the State of Western Australia, appear to reach their northern limit in the north of Shark Bay, and one of the commonest ischnochitons in South Australia is also the commonest ischnochiton on the rocks on the sheltered side of Dirk Hartog Island but has not been recorded from further north, and its extreme limit eastward is found on the northern coast of Tasmania.

NOTES ON THE FAUNA OF DIRK HARTOG ISLAND, WESTERN AUSTRALIA.

No. 2.—AVES.

(Including joint observations of Dr. A. Chenery and the writer.)

PIED CORMORANT *(Phalacrocorax varius* Gmelin, 1789.)

Nesting in great numbers on Quoin Bluff, on the ledges in the limestone cliffs; young almost fully fledged.

AUSTRALIAN PELICAN *(Pelecanus conspicillatus* Temminck, 1824).

Only a few birds seen.

RED-TAILED TROPIC BIRD *(Phaethon* (?) *rubricaudus* Boddaert, 1783).

I saw a Tropic Bird some miles out at sea and some distance south of the island, the light was not good enough to enable one to distinguish the colour of the long tail feathers but I concluded that it was the red-tailed species; as it was noticed several times, there may have been more than one bird.

The following twelve species only need be recorded:—Crested Tern *(Sterna bergii),* Fairy Tern *(Sterna nereis),* Silver Gull *(Larus Novea-Hollandiae),* Pacific Gull *(Gabianus pacificus),* Pied Oystercatcher *(Haematopus ostralegus),* Banded Plover *(Zonifer tricolor),* Eastern Curlew *(Numenius cyanopus),* (?) Whimbrel *(Numenius phaeopus),* Red-necked Stint *(Erolia ruficollis),* Sharp-tailed Stint *(Erolia acuminata),* Australian Bustard *(Eupodotis australis).*

REEF HERON *(Demigretta sacra* Vieillot, 1817).

Both the dark and the white forms were noted.

WEDGE TAILED EAGLE *(Uroaetus audax,* Latham, 1801).

WHITE-BREASTED SEA-EAGLE *(Haliaeëtus leucogaster* Gmelin, 1788).

NANKEEN KESTREL *(Falco cenchroides* Vigors and Horsfield, 1827).

OSPREY OR FISH-HAWK *(Pandion haliaëtus,* Linne, 1758).

Several pairs of these birds were seen. One pair had made their nest, consisting of almost a cart-load of sticks, on the summit of a small conical hill, locally known as "Monkey Hill," near Surf Point, the southern extremity of the island; in the nest were two fledglings with wing feathers well developed; the parent

birds continued to make loud cries as long as one was within the neighbourhood of the nest; it was a very fine sight to see these splendid birds circling round and round overhead, sometimes swooping down within fifty feet of the spectator.

HORSFIELD BRONZE-CUCKOO *(Chalcites basalis* Horsfield, 1821.)

One specimen collected by Dr. Chenery.

WELCOME SWALLOW *(Hirundo neoxèna* Gray, 1842).

These birds were nesting at the Homestead.

WHITE-FRONTED CHAT *(Epthianura albifrons* Jardine and Selby, 1828).

One nest found on a samphire-flat containing three eggs.

THE DIRK HARTOG SCRUB-WREN *(Sericornis balstoni* Grant, 1909).

Sericornis balstoni Grant (Bull. B.O.C., 23, 72, 1909, Bernier Is.).

Sericornis maculatus hartogi Carter (Bull. B.O.C., 37, 6, 43, 1916, Dirk Hartog Is.).

In September, 1928, I left my skins from Dirk Hartog Island in Melbourne for Mr. A. G. Campbell to examine, stating that at a meeting of the South Australian Ornithological Association we had come to the conclusion on the skins we had before us (two collected by Dr. Chenery and two by myself), that the Dirk Hartog *Sericornis* was worthy of being given full specific status. Mr. Campbell wrote me under date September 15, 1928:—"Mr. Ashby's skins of *Sericornis* agree with those in the H. L. White collection from Dirk Hartog Island and Bernier Island. These are distinct from *Sericornis maculatus* and are being kept so in the forthcoming biographies. Distinguishing marks are, pallid back; white ground to under-surface including under wing coverts; tail tips white all round." To this I would add that in the four examples collected, the anterior portion of the superciliary white line, common to the members of the genus *Sericornis*, is in these skins so broadened and the lores so pale as to make the lores white to dirty-white, a feature previously unknown in the genus *Sericornis*. One of the examples is a male with almost white lores. This led us to conclude that this peculiar feature was common to both sexes, but when passing through Melbourne I had the privilege of glancing through the skins in the "White Collection" and noticed there some of adult males in which the lores were darker, although still quite distinct from *S. maculatus*. I have no skins from Bernier Island, but feel justified in accepting Mr. Campbell's statement that they are conspecific with the bird on Dirk Hartog Island. Grant's name antedates that of Carter's. I have an example of Mellor's *S. m. geraldtonensis*, taken by myself at the same time and place as the holotype; this differs widely from the Dirk Hartog bird, but seems nearer that species than is the dark form of *S. maculatus* from the south-western corner of the western State.

This striking insular species was common in all places visited, it is quiet and mouse-like in its movements, but if one is still in any locality where are thick bushes, and make a few lip calls, these little birds will be seen creeping about in the shelter of the bush, coming out first in one place and then in another to have a look, often, as noticed by Carter, making a scolding note, evidently taking umbrage at the intruder.

THE DIRK HARTOG ISLAND ROCK FIELD WREN *(Calamanthus montanellus hartogi* Carter, 1916).

C. campestris hartogi Carter, Bull. B.O.C., 37, 6, 1916.

This is another of Carter's finds and is a very striking insular form nearest to *C. montanellus* Milligan, but the streaking is darker and narrower, both in

upper and lower plumage; but it differs from that species, and also from *C. campestris* and *C. isabellinus,* in the absence of rufous and buff colouration in either upper or lower plumage, and in that the ground colour of the under-side is white.

This bird was much more local than the *Sericornis,* but in the clumps of bushes where it did occur it was numerous. The male birds, in common with the allied forms on the mainland, have a very sweet song, which is produced from exposed positions on the tops of bushes, disappearing into the bush while the intruder is still a good way off; when moving in the bushes or running from one bush to another, along the ground, they cock their tails. The two I made skins of were both males, in one the iris is recorded as yellow, in the other "very pale straw colour."

Dirk Hartog Island Emu Wren *(Stipiturus malachurus hartogi* Carter).

S. m. hartogi Carter, Bull. B.O.C., 37, 6, 1916.

As compared with the Emu Wren of the mainland this subspecies is a dwarf, in fact in respect to size it seems closer to *S. ruficeps* Campbell; but in that species in the male the blue of the throat extends right round the eye and side of face, whereas in all the forms of *S. malachurus,* in the male, the feathers below the eye and side of face are never blue. The female differs widely from any other form in the pale silvery-grey ground-colour of the upper plumage, this is especially marked on the head and neck; a reference to Carter's colour plate (Ibis, 1917, pl. xi.) will show almost the correct tone of grey, but the proportion of grey to the dark streaking should be reversed, namely two of grey to one of black; the under-side of this island form is a much paler shade of buff than any mainland form. The tail of a female in my collection is even longer than that of the male, figured in Carter's plate. The full measurements of this skin are:—Total length, including tail, 150 mm.; length from tip of beak to base of tail, 50 mm.; tail, 10 mm.; wing, 39 mm.; culmen, 10 mm.; tarsus, 20 mm.; colour of iris, dark walnut; tarsus and feet, pale brown; bill, grey-black upper, horn lower. This species was first noted nearly 20 miles north of the homestead in low bushes, not far from the eastern shore of the island, but was again met with on the wind-swept downs on the western side of the island, immediately above the cliffs which there are several hundred feet in height, the great ocean rollers of the Indian Ocean breaking ceaselessly at their base. The surface of the rolling downs above is largely covered with a dwarf myrtaceous shrub which I took to be a *Thryptomene,* this dwarf shrub taking much the same place here that the heaths *(Erica* and *Calluna)* do on the moors of the British Isles. This Emu Wren shelters in these shrubs, is very shy and retiring and difficult to locate or flush, when flushed it flies with feeble flight in a straight line, its long tail held horizontally behind. We secured several females and one male, but as Whitlock failed to secure a male during his two collecting trips to the island, it is evident that the male is even more shy than the female.

The Black and White Wren *(Malurus leucopterus* Dumont, 1824).

M. leucopterus Dumont, Dict. Sci. Nat., 30, 118, 1824.

As stated in the introduction, the type of this species was taken on Dirk Hartog Island by Mons. Quoy in 1818. While this Wren is apparently present throughout the length and breadth of the island, owing to its retiring and shy habits it requires searching for. The first example I personally saw was on September 24, when a company of these little birds was noticed in some bushes on the sandhills bordering the South Passage at the southern extremity of the island, less than half a mile from Surf Point; the width of the channel here separating the island from the mainland is stated by Carter to be "barely a mile."

As neither Carter or Whitlock seem to have done any collecting on this southern end of the island, this observation, so near to the mainland, is of importance; there is no doubt as to the identification, for one or more of the black and white males were easily seen in this small flock.

To the north and west of the homestead we saw many birds and secured a nice series of skins. At one point near the eastern shore several cock birds, with the attendant females, were noticed in low bushes growing on small hillocks of sand, separated from one another by samphire flats. Then again, I noticed several males well up on the elevated western downs bordering the Indian Ocean. The population of Black and White Wrens on this island must run into scores of thousands; the "cats gone wild" mentioned by Whitlock, I am thankful to say, do not seem in any degree to have diminished the numbers of this extremely interesting form of *malurus*.

Habits.—As before mentioned, these birds go in companies containing a number of females and young males, in plain brown upper plumage and almost white under, with one or more adult males dressed seemingly, entirely in black and white, except the tail feathers which are deep blue. These adult males are very shy but have the habit of perching upon the topmost branches of the bush they happen to be in, and watching the intruder at a distance, or if disturbed when the intruder is nearer, they quickly disappear into the shelter of the bush, making their exit near the ground on the opposite side and thus passing through bush after bush if small, or remaining hidden if a large bush; in fact, they are adepts at doing a sort of disappearing trick; it requires the greatest vigilance of the observer if he is to keep in touch with the bird at all. It was also noted that the black plumage is inconspicuous except when the observer is quite near, and the pure white wing coverts are also invisible except when seen against a dark background. The plain plumaged birds, to a certain extent, scatter when disturbed, but whether this is due to any warning call of the male or not I could not ascertain.

Description.—None of the cock birds collected by us show any blue except in the tail, the pure white wing patch is made up, according to Mathews, of "inner upper wing coverts, scapulars, upper-back, and innermost secondary quills"; the flight quills are brown and rest of both upper and under plumage is intense black, but the crown of the head has a distinct sheen-like satin. The measurements and data of a male were made in the flesh. Total length, tip of beak to tip of tail, 120 mm.; wing, 41 mm.; tail, 57 mm.; culmen, 9·5 mm.; tarsus, 21 mm.; iris, brown; feet, dark horn; tarsus, horn colour; bill, black. In the female the bill is reddish-horn; iris, feet and tarsus, same as male.

Discussion.—Several theories have been proposed to explain the existence on both Dirk Hartog Island and Barrow Island, separated, as they are, by 400 miles of sea, of a Black and White Wren endemic to these two islands and occurring nowhere else. Are they survivals of a primitive form which has disappeared on the mainland, or are they, as I believe, representatives of a mainland species that has, owing to special ecological conditions common to these two widely-separated islands, changed in its plumage from deep blue and white to black and white. In advancing this hypothesis, I am able to advance some data from my own collection which has encouraged me to propound this theory as against that of survival.

I have in my collection skins of three males from different localities on the mainland of Western Australia of the Blue and White Wren (*M. cyanotus* Gould, 1865), all show a much deeper blue than do examples from South Australia. One, from the coast hills 160 miles north of Perth, shows many almost black feathers intermingled with the blue, and a male I collected on Peron Peninsula on September 29, 1927, 300 miles further north than the preceding example, is

so dark in colour that it looks black in some lights; in fact, I have several times picked up this skin thinking it was one of the Dirk Hartog Island specimens, until I altered the angle of light. It will be noted that only 20 miles of water separate the two localities.

As before stated, barely a mile of water separates the island at its southern extremity from the mainland, it seems almost certain that gales will at times drive the Blue and White Wren from the mainland to the island or the island bird on to the mainland. In face of the evidence advanced which indicates a gradual transition from lighter blue to darker in the western examples of *M. cyanotus,* evidences that this tendency is emphasised as one proceeds northwards along the coastal belt, we are surely justified in assuming that this melanote tendency attains its maximum development on the two islands named owing to the presence there in excess of the inducing cause or causes. It is interesting to note that the females of the two species are practically identical.

The Dirk Hartog Island Purple-backed Wren *(Malurus assimilis hartogi* Mathews, 1918).

Malurus lamberti hartogi Mathews, Bull. B.O.C., 39, 24, 1918.

Several examples of both male and female were secured; their plumage is exceptionally brilliant, the blue around the eye and cheek is a little different in shade from any examples I have seen from South Australia, and in this subspecies this shade of blue extends along the margin of the crown. I notice that Carter identified his specimens from Dirk Hartog Island with the subspecies *occidentalis* Mathews, 1912. Not having seen examples of *occidentalis,* I cannot express an opinion as to whether Mathews was justified in separating it, nevertheless, recognising that the insular bird warrants subspecific separation from the South Australian, I accept Mathews' name, *hartogi.* We found these Wrens shy, but noted them in several localities a good many miles apart.

. Western Silvereye *(Zosterops australasiae* Vieillot, 1817).

Sylvia australasiae Vieillot, Nouv. Dict., 11, 235, 1817.

These birds were very numerous on the island and may be presumed to represent Mathews' subspecies *edwini* from Carnarvon, only 80 miles to the north-east. In the two examples we collected on the island, I cannot note any differences from skins taken from the mainland further south.

Brown Honeyeater *(Gliciphila indistincta* Vig. and Hors., 1827).

Only seen at 12-mile well, where Carter camped.

Singing Honeyeater *(Meliphaga virescens* Vieillot, 1817).

Melithreptus virescens Vieillot, Nouv. Dict., 14, 329, 1817, Shark Bay, W.A.

This was much the commonest bird on the island. We did not collect any specimens on the island but did collect several on Peron Peninsula, just 20 miles across the water. It is understood that the type described by Vieillot was taken on the same peninsula. I notice that Mathews, in 1920, separated the bird on the island under the subspecific name *hartogi,* but such a strong flying bird is not likely to have been isolated from the mainland.

The Australian Pipit *(Anthus australis* Vieillot, 1818).

These birds were fairly common, but one example only was taken; this skin does not exhibit any features separating it from the mainland birds, which from

the same localities show a fairly wide margin of variation; I am, therefore, not adopting Mathews' subspecific name of *hartogi.*

ZEBRA FINCH *(Taeniopygia castanotis).*

This species was common at the wells, but one example only was collected on the island; the same species was also numerous on Peron Peninsula, but I cannot note any characters distinguishing examples I secured there and on the Murchison from the form we have in South Australia, so am not making use of Mathews' name *hartogi.*

LITTLE CROW *(Corvus bennetti)* (?).

We did not collect any specimens on the island, and therefore the identification of the island bird with this crow is uncertain. As there are no trees on the island, the crows we saw were nesting on most of the windmills.

NOTES ON THE FAUNA OF DIRK HARTOG ISLAND, WESTERN AUSTRALIA.

No. 3.—POLYPLACOPHORA.

ACANTHOCHITON BEDNALLI JOHNSTONI Ashby.

Acanthochiton bednalli, var. *johnstoni,* Ashby (Trans. Roy. Soc. S. Austr., vol. xlvii., p 231, 1923).

This shell was described by the writer as a variety of *A. bednalli,* from three examples that were collected by W C. Johnston at about half way between Carnarvon and Maud Landing; I now suggest treating this western form as a subspecies.

Definition.—Differs from *A. bednalli* s.s., in that the dorsal area in this form, from the beak forwards for about half the length, is ornamented with longitudinal rows of elongate, squamose granules, which then for a short distance in some examples shows a little longitudinal grooving which is replaced by a smooth surface, except for transverse growth ridges. The consistent deep longitudinal grooving, that is so typical of *bednalli,* is in this form absent; also, the fringe spicules of the girdle are decidedly coarser than *bednalli* s.s. This description is made from an example collected by the writer at Woodman's Point, near Fremantle, because the type from North of Carnarvon had the dorsal area eroded, this example now becomes the neotype.

Two juvenile examples were obtained on rocks, at low tide, four miles south of the homestead on the island. The smaller, which measures only 3 mm. in length, possesses such a broad dorsal area that it is with hesitation that the writer assigns it to this species, but the larger, which is curled and measures about 5 mm. in length, seems quite typical of this subspecies.

NOTOPLAX SUBVIRIDIS Torr.

Acanthochites subviridis Torr (Trans. Roy. Soc. S. Austr., vol. xxv., p. 104, 1911).

One example in excellent preservation, measuring, dry, 12·5 mm. in length, was obtained four miles south of the homestead, it is a typical specimen. The occurrence of this rare *Notoplax* at Dirk Hartog Island extends our knowledge of its range of habitat nearly 600 miles northwards. The only previous records were the four specimens collected by Torr at Albany, 1910, and three by the writer at Yallingup in 1929.

Ischnochiton cariosus Pilsbry, 1892.

Iredale and Hull make Dall the author of the name *cariosus,* but as far as I can ascertain this name as used by Dall was a *nomen nudum,* in which case the author is Pilsbry, 1892.

The action of Iredale and Hull in giving generic rank to the name *Heterozona* has not up to the present been justified by any definitions supplying distinctions of generic status. Pilsbry (Man. Con. xiv., p. 65) treated *Heterozona* as a subgenus of the genus *Ischnochiton,* proposed by Dall, 1873 (Table of Regular Chitons, 1873), Pilsbry accepting the name as of subgeneric value on account of the "girdle bearing small scales with large striated scales intermingled," but later, in vol. xv., p. 82, he treats the name *Heterozona* as a section of the genus *Ischnochiton* only.

As the two other species which Iredale and Hull include in their genus *Heterozona,* namely *I. fruticosus* and *I. subviridis,* neither possess the character of "intermingled large girdle scales," such treatment is without justification. The main character on which Pilsbry's section *Heterozona* was founded, "the intermingling of large scales," seems to be in this case only a specific character, which does not occur in *I. fruticosus,* its nearest ally.

Ischnochiton cariosus, var. occidentalis, Ashby.

Ischnochiton (Heterozona) cariosus, var. *occidentalis,* Ashby (Trans. Roy. Soc. S. Aust., vol. xlv., pp. 41-2, 1921).

Of this variety six examples were taken at 4 miles south of the homestead and at Surf Point, the southern extremity of the island. These all show the stronger sculpture characteristic of this variety, which the writer has now collected at the following localities on the western coasts of the western State:—Ellensbrook, Yallingup, Rottnest Island, Dongarra, Geraldton, and now as far north as Shark Bay on Dirk Hartog Island. The limits of the range of *I. cariosus* correspond with the limits proposed by the writer for his Indo-Australian Region, interlapping with the Adelaide Region (A. Ass. Adv. Sci., vol. 17, p. 374, 1924).

The largest of the Dirk Hartog Island shells measures 22 x 12 mm., this example showing none of the "large scales," although the next smaller in size exhibits this feature. Sufficient collecting has not been done along the southern coast of Australia to determine whether *occidentalis* deserves subspecific rank or whether it is only the extreme of a gradual variation.

Ischnochiton tindalei Ashby.

Ischnochiton tindalei Ashby (Trans. Roy. Soc. S. Austr., vol. xlviii., p. 323-4, 1924).

Two examples were obtained of this shell, that has hitherto been only known from the damaged holotype from Groote Eylandt in the Gulf of Carpentaria; these two were obtained on rocks at low tide four miles south of the homestead.

This species is near to *I. luticolens* Hull, but is separable by the character of the sculpture and the more raised lateral areas; the granules in the lateral areas and end valves in *I. luticolens* are shallow and flattened, whereas in *I. tindalei* they are strongly convex; this character, although in a less degree, applies to the sculpture of the other areas; also, in *I. tindalei,* the grains are more crowded. The two examples from Dirk Hartog Island are hardly as strongly sculptured as is the type, this may be due to juvenility, or it may be that when a larger series is available sufficient variation in *I. tindalei* may be found to cause one to grant this form subspecific rank only. The two examples under discussion have not been disarticulated, so I cannot say whether they show the same distinction in the slitting of the insertion plate that was noticed in the holotype.

Cryptoplax hartmeyeri Thiele.

Thiele (Die Fauna Südwest-Australiens, Polyplacophora, Band iii., L. ii., pp. 405-6, 1911).

Dr. J. Thiele, in his description, records three examples collected by Drs. Michaelsen and Hartmeyer; one came from Surf Point, the southern extremity of Dirk Hartog Island, but the locality of the other two is unknown, probably also from Shark Bay. These three specimens have hitherto been the only examples known, and are, I understand, in the Berlin Museum.

I was successful in collecting two at Surf Point (the type locality), and one between that spot and the homestead, about four miles south of the latter. Those from Surf Point measure, respectively, dry, 45 and 25 mm. in length, and were taken off limestone or coral rock at low water, on the inner side of Surf Point on the island side (north) of the South Channel. The third example was found almost completely buried in the hole of some rock borer, in a piece of hard limestone, at four miles south of the homestead; the animal so completely filled the hole into which it had forced its way that it was with much difficulty got out without damage, and is now preserved in spirit. This example only measures, in its curled condition, 20 mm. in length, although really the second largest of the three taken. Valves 5, 6, and 7 are in this specimen as in life and show as mere spots, nearly buried in the spiculose girdle. I cannot distinguish between this and the figure in Reeve's Icon., 1847, *Chitonellus,* pl. i., fig. 3, which figure is understood to represent *C. burrowi* Smith.

Thiele, while admitting that *C. hartmeyeri* is nearly allied to *C. burrowi,* says "the valves and also the spicules on girdle are distinctly different," but it is unfortunate that he does not indicate the characters of these differences. Unfortunately, I have never seen an example of *C. burrowi,* neither have I seen drawings or descriptions of the characters of the girdle spicules of that species and, therefore, am not in a position to express any opinion. In 1924 (l.c. vol. xlviii. pp. 239-240) the writer described and figured a minute *Cryptoplax* from about 30 miles north of Carnarvon, North Shark Bay, suggesting that it might be identified with the still more minute form partially described by Thiele under the name *C. michaelseni,* in 1911. I now realize that, although the valve sculpture of this juvenile specimen from north of Carnarvon appears to differ considerably from adult *C. hartmeyeri,* the peculiar flattened, adpressed spicules, whose character was especially emphasised in my description in 1924 l.c., correspond exactly with those of *C. hartmeyeri,* of which I now have specimens. The fact that in the juvenile form all the valves touch one another, did not at all suggest that species, in which the last four valves are so widely separated, but now I am satisfied that this Carnarvon example is the juvenile form of *C. hartmeyeri.*

Cryptoplax michaelseni Thiele.

Thiele (Die Fauna Südwest-Australiens, l.c.p. 404, pl. vi., figs. 11-17).

I called Dr. Thiele's attention to the statement of Iredale and Hull: "That the Thielean figures here reproduced absolutely prove that Thiele's species is not a *Cryptoplax.*" To this Dr. Thiele replies, under date June 25, 1928: "The foremost part (anterior valve) has three incisions (slits), all the rest are without them; in my opinion the species should be placed in *Cryptoplax.*"

With the additional light thrown upon the subject by the discovery that the juvenile shell from north of Carnarvon is the juvenile stage of *C. hartmeyeri,* I have re-examined Thiele's figs. of his *C. michaelseni* and, if as seems probable, his specimen was one-third only the size of Ashby's Carnarvon shell, the figures would fairly well represent a juvenile shell of *C. hartmeyeri* of about 2 mm. in length. Also Thiele's figures of the spicules of the two species closely correspond with each other, if one allows for the extra magnification of the spicules

of *C. michaelseni,* which is two to three times that of his figures of *C. hartmeyeri.* Thiele explains that he was quite unaware that the minute specimen he called *C. michaelseni* was a *Cryptoplax* until the disarticulation of the valves revealed the fact that the insertion plates were those of a *Cryptoplax* and not those of an *Acanthochiton,* this probably accounts for the omission of full measurements of the animal.

In conclusion.—I have demonstrated that *C. hartmeyeri* possesses a specialized form of girdle spicule which is flat, adpressed, and grooved; that this peculiar form of spicule also clothes the girdle of Ashby's shell which he identified with *C. michaelseni* Thiele, and now the additional study of Thiele's figures supports the assumption that the minute type of *C. michaelseni* also possessed similar specialized girdle spicules. In face of these facts, we have to consider that these are different stages of growth of one species, and we have reached the following conclusions:—

(a) That Iredale and Hull referred *C. michaelseni* to the genus *Acanthochiton* without the slightest supporting evidence.

(b) That Ashby's shell, which he identified with *C. michaelseni,* is conspecific with *C. hartmeyeri.*

(c) That *C. michaelseni* is the very juvenile form of *C. hartmeyeri.*

(d) Unfortunately, *C. michaelseni* has page precedence over *C. hartmeyeri,* which, under International rules, necessitates our accepting *C. michaelseni* Thiele, as the name of the shell, *C. hartmeyeri* becoming a synonym thereof.

Lophochiton johnstoni Ashby.

Lophochiton johnstoni Ashby (Trans. Roy. Soc. S. Austr., vol. xlvii., 233-6, 1923).

Iredale and Hull propose to recognise in this shell, *Chiton coccus* Menke, a species that was never figured and the type of which was lost. Menke's description will equally apply to Hull's *Callistochiton granifer,* to Thiele's *Callistochiton recens,* or almost any *Callistochiton. C. recens* Thiele was described from Shark Bay in 1911, *L. johnstoni* Ashby from same locality in 1923, and *L. granifer* Hull described as a *Callistochiton* from Queensland, also in 1923, but publication of his name precedes Ashby's by a few months.

I prefer to follow Pilsbry and relegate *C. coccus* Menke to the list of "Insufficiently described chitons, and species of unknown generic position." Thiele's *C. recens* was not figured but, as the type is still in existence, I sent one valve of the holotype of *L. johnstoni* and the single example taken by the writer on pearl-shell, dredged in Shark Bay, during the trip. also a specimen of Hull's *granifer* for comparison with Thiele's type. He writes me as follows:—"My *Callistochiton recens* appears to differ from the *Lophochitons granifer* and *johnstoni* in the weaker sculpture and the relatively broader and shorter middle valve, without noticeable radiable ribs."

I only secured the single example off pearl-shell that had been dredged in the bay between Dirk Hartog Island and the mainland; my opportunity of examination was limited to about half an hour, more available time would probably have led to further discovery. The specimens obtained 11·5 x 8 mm., the radial ribbing in the anterior valve is shallower than in *L. granifer,* as are also the two radial ribs in the lateral areas.

In conclusion.—A reference to the description of the type (p. 236) will show that the writer separated *L. johnstoni* from *C. recens,* not on lack of correspondence but on the existence in *L. johnstoni* of several striking characters unmentioned by Thiele, the most important of which was the absence of "festooning" in the insertion plate of the anterior valve, a feature that is present in the genus

Callistochiton; as Hull overlooked the absence of this feature in his description of his *granifer,* it is not impossible that Thiele did the same. Now, in comparing the examples sent, Dr. Thiele only mentions as separating characters in his shell, "weaker sculpture and the relatively broader and shorter middle valve." In respect to sculpture, I have already shown herein that the sculpture of *johnstoni,* especially in the ribbing of the lateral areas in the recent example, is much weaker than *L. granifer;* in fact, unless viewed with lateral lighting, the existence of radial ribbing in the lateral areas is imperceptible.

With regard to the proportional longitudinal and lateral measurements, these vary greatly in the median valves of Ashby's type, the single valve sent to Dr. Thiele was longitudinally considerably longer than any of the others; this will account for the apparent difference noted by Thiele. If Thiele's *C. recens* is without "festooning" in the insertion plate of the anterior valve it is certainly a *Lophochiton,* and coming, as it does, from the same locality, namely Shark Bay, both it and Ashby's *L. johnstoni* may safely be considered conspecific. As a result of this discussion we have:—

(a) *Solivaga recens* Thiele of Iredale and Hull becomes *Lophochiton recens* Thiele; their genus *Soliviga* has no known Australian representative, even if it has any justification at all.

(b) Ashby's *Lophochiton johnstoni* becomes a synonym of *Lophochiton recens* Thiele, as was rather anticipated in his type description.

(c) *Callistochiton granifer* Hull becomes a very good subspecies of *Lophochiton recens* Thiele.

Tonica (Lucilina) dilecta Thiele.

Lucilina dilecta Thiele (Die Fauna Südwest-Australiens, iii., p. 397, 1911).

No adequate characters of generic values seem to have been advanced to justify generic separation of *Lucilina* from *Tonicia,* but with some hesitation I am retaining *Lucilina* as having subgeneric status.

Three small specimens were taken off the rocks at low tide four miles south of the homestead, and over a dozen from the same heap of pearl-shell that had been dredged in deeper water, that has before been referred to, these all will be topotypes, as Shark Bay is the type locality. The smallest example, 5 mm. in length, is worthy of mention, it was from the rocks four miles south of the homestead, is of a beautiful pink colour mottled with lighter and darker markings, is much longer in proportion to width than usual, and the lateral areas are strongly raised, showing little if any of the typical sculpture.

Onithochiton quercinus occidentalis, n. sub-sp.

A new name for the *Onithochiton* from Western Australia = *O. scholvieni* Thiele (Die Fauna Südwest-Australiens, iii., p. 1, 1911. Non of Thiele Rev. Chitonen, Chun's Zool. Heft 56, pl. ii., 1910).

Dr. Thiele writes me under date June 25, 1928, in reference to well-preserved examples of this *Onithochiton* I sent him from the north of Shark Bay:—"The small *Onithochitons* from Carnarvon I consider, because of their weak sculpture, not to be *O. scholvieni,* which species, as I have written before, comes from Vaucluse, and also from Sydney." *O. scholvieni* Thiele is, therefore, a synonym of *O. quercinus* Gould, as there is only one species known in that locality.

The known range of *O. quercinus* extends from south of Sydney, in New South Wales, to Mackay, in Queensland. The known range of the Western Australian species extends from Esperance on the South coast, up the west coast to a spot half way between Carnarvon and Maud Landing. This leaves a gap

around the coastline (not following the indentations) of 1,200 miles in Western Australia, 1,100 miles in the Northern Territory, and 1,500 miles in Queensland, or approximately 3,800 miles of coastline between the habitats of the two forms, throughout which immense area of coast, up to the present, we have no knowledge of the presence of either of these species. This fact, combined with the general difference of sculpture, leads one to conclude that we are justified in recognising the western form as at least deserving subspecific separation.

Differences.—I concur in the main with Dr. Thiele in his statement that the western form is weaker than its congener in the east, but I admit, with Iredale and Hull, that very wide variation exists on the eastern species, but on the other hand the western species, in the adult stage, with rare exceptions, is much less sculptured than is the eastern form; in fact, normally the lateral areas in the western are almost, if not quite, unsculptured. Again, the western, which I propose to call *occidentalis,* normally attains a larger size; in fact, the large examples are much the most common. An examination of the respective girdles under 65 mag. leads me to conclude that while the girdles of both forms are densely clothed with shortish, stout, pointed spicules, those on the eastern shells are shorter and stouter in proportion, and also that *O. quercinus* s.s. normally possesses, amongst others, one particular class of spicule that does not occur in *occidentalis,* namely, very short, very stout spicules, usually placed in considerable patches; these spicules either taper abruptly to a fine point or have rounded, knobby apices; these round-ended spicules suggest that the fine point has been broken off at an early stage and then mended by a redeposition of calcareous matter making a well-finished rounded apex, but I doubt whether this is a true explanation of the occurrence.

This *Onithochiton* was very common on the exposed western side of the reef at Surf Point, Dirk Hartog Island. I have selected as the holotype of this subspecies an example collected by myself at Dongarra, Western Australia, on November 10, 1920, taken from the exposed outer reef.

Liolophura hirtosus (Peron M. S.) Blainville.

Chiton hirtosus Blainville (Dict. Sci. Nat., xxxvi., 1825).

Clavarizona was proposed as a generic name for the reception of this species by Hull (Aust. Zool., iii. p. 199, 1923). Ashby in (Jour. and Proc. Roy. Soc. W. Austr., vol. viii., pp. 32-3, 1921-2) shows that *L. hirtosus* is typically a *Liolophura,* and gives a detailed description of the insertion plate of the tail valve. The characters defined by Hull as justifying his proposed erection of his genus *Clavarizona* are certainly beneath generic status and, therefore, the generic name of *Clavarizona* cannot be accepted. This species was exceedingly numerous on the outer side of the bar at Surf Point, in the same rock holes as the *Onithochiton.*

NOTES ON THE FAUNA OF DIRK HARTOG ISLAND, WESTERN AUSTRALIA.

No. 4.—CRUSTACEA.

By Herbert M. Hale, Curator, South Australian Museum.
(Contribution from the South Australian Museum.)

Plate V.

[Read May 9, 1929.]

A few crustaceans were collected by Mr. Edwin Ashby during his recent short visit to Dirk Hartog Island and, at his request, the species are herein dealt with. Apart from material secured on or near the shores of the island, Mr. Ashby also obtained two crabs, *Halicarcinus ovatus* Stimpson and *Schizophrys aspera* H. M. Edwards, off Woodman's Point, near Fremantle.

The following species belong to the fauna of Dirk Hartog Island:—

Family SQUILLIDAE.

Only one representative of the family was found by Mr. Ashby, but it may be of interest to mention that Mr. D. L. Serventy, of Perth, recently collected a specimen of *Squilla laevis* Hess [1], at Cottesloe Beach, Western Australia.

Gonodactylus glabrous Brooks.

Gonodactylus glabrous Brooks, Zool. Rep. Voy. "Challenger," xvi., 1886, p. 62, pl. xiv., fig. 5, and pl. xv., figs. 7-9; Kemp, Mem. Ind. Mus., iv., 1913, p. 167, pl. ix., fig. 113 (and syn.).

A female with the colouration as follows:—Dorsum and raptorial limbs bright green, the latter with the dactylus pink at base and greenish distally; underside and all other appendages yellow, in parts tinged with green.

Family HIPPOLYTIDAE.

Alope australis Baker.

Alope palpalis Hasw., Cat. Aust. Crust., 1882, p. 193 (*nec* White).

Alope australis Baker, Trans. Roy. Soc. S. Austr., xxviii., 1904, p. 154, pl. xxx., figs. 1-7; McCull., Rec. Aust. Mus., vii., 1909, p. 313, fig. 17; Kemp, Rec. Ind. Mus., x., 1914, p. 91, pl. i., figs. 3-5; Stebb., Ann. Durban Mus., ii., 1919, p. 121, pl. xix. and iii., 1921, p. 22, fig. 5.

Four specimens, the largest 35 mm. in length.

Hippolysmata vittata Stimpson.

Hippolysmata vittata Kemp, Rec. Ind. Mus., x., 1914, p. 113, pl. vi., figs. 6-10 (and syn.).

A single specimen, about 30 mm. in length and in a soft state of preservation, represents a variety with the second legs much divided as in specimens from the Andamans described by Kemp. [2]

In this case, however, these limbs are not asymmetrical; the ischium is indistinctly annulated by eight inconspicuous divisions, the merus has twenty-three to twenty-four divisions, and the carpus is twenty-nine to thirty jointed.

(1) Kemp, Mem. Ind. Mus., iv., 1913, p. 49, pl. iii., figs. 35-37 (and syn.).
(2) *H. vittata*, var. (?) Kemp, Rec. Ind. Mus., x., 1914, p. 115.

Family SYNALPHEIDAE.

Crangon edwardsi (Audouin).

Alpheus edwardsi (Aud.) de Man, Journ. Linn. Soc., Zool., xxii., 1888, p. 266 (and syn.).

Family PORCELLANIDAE.

Petrolisthes japonicus (de Haan).

Porcellana japonica de Haan, in Siebold's Fauna Japon, Crust., vii., 1849, p. 199, pl. i., fig. 5.

Petrolisthes boscii (Audouin).

Porcellana boscii Audouin, Savigny, Descr. d. l'Egypte, Crust., 1826, p. 89, for Savigny's pl. vii., fig. 2.

Petrolisthes boscii McCull., Rec. Aust. Mus., ix., 1913, p. 353, fig. 53.

Family LITHODIDAE.

Lomis hirta (Lamarck).

Lomis hirta (Lamarck) Hasw., Cat. Aust. Crust., 1882, p 152 (and ref.); Hale, Crust. S. Aust., pt. i., 1927, p. 96, fig. 93.

A single small specimen was taken under a stone between tide-marks. The species was previously known to range from Tasmania and Victoria to the shores of the Great Australian Bight, but the new locality considerably extends its known habitat.

Family PAGURIDAE.

Clibanarius virescens (Krauss).

Pagurus virescens Krauss, Südafrik. Crust., 1843, p. 56, pl. iv., fig. 3.

Clibanarius virescens McCull., Rec. Aust. Mus., ix., 1913, p. 346, pl. xi., fig 2 (and syn.).

Calcinus latens Randall.

Calcinus latens Randall, Journ. Acad. Nat. Sci., Philad., 1839, p. 135; Alcock, Cat. Ind. Decapod Crust., ii., 1905, p. 58, pl. v., fig. 5.

Calcinus terrae-reginae Hasw., Proc. Linn. Soc., N.S. Wales, vi., 1882, p. 57; Alcock, *loc. cit.*, p. 57, pl. v., fig. 7.

The eye-stalks of the single small specimen secured are shorter than as shown by Alcock; no other differences are apparent, and this character is probably due to youth.

Family MAJIDAE.

Menaethius monoceros (Latreille).

Menaethius monoceros (Latr.) Alcock, Journ. Asiat. Soc. Bengal, lxiv., 1895, p. 197 (and syn.).

Cyclax suborbicularis (Stimpson).

Cyclax suborbicularis (Stimps.) Alcock, Journ. Asiat. Soc. Bengal, lxiv., 1895, p. 245; Calman, Trans. Linn. Soc., viii., 1900, p. 39 (and syn.).

Family XANTHIDAE.

Actaea michaelseni Odhner.

Actaea michaelseni Odhner, Göteborgs Kungl. Vet.-Och. Vitt.-Samh. Handl., xxix., No. 1, 1925, p. 43, pl. v., fig. 4.

The unique female type was taken in Shark Bay, Western Australia, and Mr. Ashby now presents a second female from Dirk Hartog Island, in the vicinity of the type locality. This example has the carapace 15 mm. in length and 21 mm. in breadth, and agrees closely with Odhner's description and illustration. In colour, it is salmon red above, with the fingers of the chelae brown, tipped with white, and the claws of the walking legs brown.

ACTAEA CAVIPES (Dana).

Actaeodes cavipes Dana, Proc. Acad. Nat. Sci., Philad., 1852, p. 73.
Actaeodes cellusosa Dana, *loc. cit.*
Actaea fossulata (Girard) Alcock, Journ. Asiat. Soc. Bengal, lxvii., 1898, p. 148.
Actaea schmardae Heller, Abh. Zool.-bot. Ges. Wien, 1861, p. 6.
Actaea cavipes A. M. Edw., Nouv. Archiv. du Mus. Paris, i., 1865, p. 280; Odhner, Göteborgs Kungl. Vet.-Och. Vitt.-Samh. Handl., xxix., 1925, No. 1, p. 68.
Glyptoxanthus cymbifer Rath., Proc. Zool. Soc., 1914, p. 658, pl. i., fig. 6, and pl. ii., fig. 7.

XANTHIAS LAMARCKII (H. M. Edwards).

Xantho lamarckii H. M. Edw., Hist. Nat. Crust., i., 1837, p. 391.
Xanthodes lamarckii Alcock, Journ. Asiat. Soc. Bengal, lxvii., 1898, p. 157 (and syn.).

XANTHIAS ELEGANS (Stimpson).

Xanthodes elegans Stimps., Proc. Acad. Nat. Sci., Philad., x., 1858, p. 33; and Smithson. Misc. Coll., xlix., No. 1717, 1907, p. 47, pl. v., fig. 3.
Xanthodes atromanus Hasw., Cat. Aust. Crust., 1882, p. 49, pl. i., fig. 1.
Xanthias elegans Odhner, Göteborgs Kungl. Vet.-Och. Vitt.-Samh. Handl., xxix., No 1, 1925, p. 84.
Xanthias atromanus McNeill, Aust. Zool., iv., 1926, p. 313.

Previously, all Australian authors have dealt with this species under Haswell's name, *X. atromanus*.

CARPILODES CINCTIMANUS (White).

Carpilius cinctimanus White, in Jukes Voy. "Fly," ii., 1847, p. 336, pl. ii., fig. 3.
Liomera cinctimana Alcock, Journ. Asiat. Soc. Bengal, lxvii., 1898, p. 88 (and syn.).
Carpilodes cinctimanus Odhner, Göteborgs Kungl. Vet.-Och. Vitt.-Samh. Handl., xxix., No. 1, 1925, p. 14.

The single male secured has a carapace 5 mm. in length and 9 mm. in breadth. When fresh, the colouration of this example was as follows:—Carapace white, with four narrow, wavy, longitudinal orange lines, not reaching to posterior margin; innermost pair extending to anterior edges of frontal lobe, and outermost reaching to middle of hinder margin of orbit, which is encircled by an orange line; on each side there is a short oblique orange marking from the outer margin of the orbit. Legs orange, fingers brown.

The colouration is rather unusual, notwithstanding the fact that the species exhibits considerable variation in this respect. Apart from this the specimen fits well in the key furnished by Odhner *(ut supra)*.

CARPILODES RUBER A. M. Edwards.

Carpilodes ruber A. M. Edw., Nouv. Archiv. du Mus. Paris, i, 1865, p. 228, pl. xi., fig. 4; Odhner, Göteborgs Kungl. Vet.-Och. Vitt.-Samh. Handl., xxix., No. 1, 1925, p. 23, pl. ii., fig. 2.
Carpilodes coccineus Rath., Bull. U.S. Fish. Comm. for 1903 (1906), pt. iii., p. 843, pl. viii., fig. 4.

An adult male. The body is not uniformly dark red, but has a broad median band (about one-third of the total width) of white, sparsely marked and spotted with red; this pale area extends below on to the abdomen. The rest of the carapace and the legs are red, with the exception of the fingers of the chelae which are brown, tipped with white. Mr. Ashby states that the red was deep crimson during life.

CARPILODES RUGATUS (H. M. Edwards).

Zozymus rugatus H. M. Edw., Hist. Nat. Crust., i., 1834, p. 385.
Carpilodes rugatus A. M. Edw., Nouv. Archiv. du Mus. Paris, i., 1865, p. 230, pl. xii., fig. 3; Odhner, Göteborgs Kungl. Vet.-Och. Vitt.-Samh. Handl., xxix., No. 1, 1925, p. 20, pl. i., fig. 16 (and syn.).
Carpilodes monticulosus Alcock, Journ. Asiat. Soc. Bengal, lxvii., 1898, p. 86 *(nec. M. Edw., 1873)*.

A male and a female, with the colouration as described by Alcock, were taken by Mr. Ashby at Dirk Hartog Island.

Odhner states that, following Alcock, there has been confusion between this species and *C. monticulosus;* the mid-Pacific records of the latter by Rathbun and Edmondson particularly are referable to *C. rugatus.* I have examined specimens of *C. rugatus* in the Australian Museum, Sydney, which were received in exchange by that institution through Ch. Edmondson of Ber. P. Bishop Mus., Honolulu, and incorrectly named by him *C. monticulosus.*

Chlorodiella niger (Forskal).

Cancer niger Forskal, Descr. Anim., 1775, p. 89.

Chlorodius niger Alcock, Journ. Asiat. Soc. Bengal, lxviii., 1898, p. 160 (and syn.).

Chlorodiella niger Rath., Bull. U.S. Fish. Comm., xxiii. for 1903, pt. iii., 1906, p. 857.

Chlorodopsis areolata (H. M. Edwards).

Chlorodius areolatus H. M. Edw., Hist. Nat. Crust., i., 1834, p. 400 ("Nouvelle-Hollande").

Etisodes caelatus Dana, U.S. Expl. Exped., Crust., i., 1852, p. 188, pl. ix., fig. 4 ("Wakes Id., Pacific Ocean"); (?) Whitelegge, Mem. Aust. Mus., iii., 1897, p. 131.

Actaeodes affinis Dana, U.S. Expl. Exped., Crust., i., 1852, p. 197, pl. xi., fig. 3 (Paumotu Group—Low Archipelago).

Chlorodopsis areolatus Hess, Archiv. für Naturg., Jahrg., xxxi., 1865, p. 135; A. M. Edw., Nouv. Archiv. du Mus. Paris, ix., 1873, p. 231, pl. viii., fig. 8; Hasw., Cat. Aust. Crust., 1882, p. 54; Miers, Zool. "Alert," 1884, pp. 217 and 532 (and refs.); Whitelegge, Journ. Roy. Soc., N.S. Wales, 1889, p. 227; Ortman, Zool. Jahrb., Syst., vii., 1893, p. 470; Rath., Bull, U.S. Fish. Comm., xxiii. (3, 1903), 1906, p. 858; Bouvier, Bull. Sci. Fr. Belg., xlviii., 1915, p. 278.

Chlorodopsis areolata Alcock, Journ. Asiat. Soc. Bengal, lxvii., 1898, pp. 165-166 (and refs.); Nobili, Mem. Acc. Sci. (2), lvii., 1908, p. 396, pl. ii., fig. 3; Odhner, Göteborgs Kungl. Vet.-Och. Vitt.-Samh. Handl., xxix., No. 1, 1925, p. 36.

Actaea affinis Hasw., Cat. Aust. Crust., 1882, p. 45; Whitelegge, Journ. Roy. Soc., N.S. Wales, 1889, p. 230; Borrad., Fauna Mald. & Laccad. Arch., i., 1901, p. 254; Grant and McCull., Proc. Linn. Soc., N.S. Wales, xxxi., 1906, p. 11; Rath., Bull. U.S. Fish. Comm., xxiii. (3, 1903,), 1906, p. 852, and (in Stimpson) Smiths. Misc. Coll., xlix., 1907, p. 43, and Mem. Mus. Comp. Zool., xxxv., No. 2, 1907, p. 42, and Proc. Zool. Soc., 1914, p. 658, and Trans. Linn. Soc., London, xiv., 2, 1911, p. 219; Balss, Archiv. für Naturg., 88 Jahrg., 1922, Abt. A, heft xi., p. 121; Edmondson, Bull. Ber. P. Bishop Mus., v., 1923, p. 15.

Odhner *(ut supra)* notes that there has been considerable confusion between *Actaea affinis* and *Chlorodopsis areolata.* Miers [3] wrongly places *Actaeodes affinis* Dana and *Actaea affinis* A. M. Edw. as synonyms of "*Actaeodes tomentosus* H. M. Edw." Probably a few references to "*Actaea affinis* Dana" are missed in the above synonymy, but all, if correctly identified, are referable to *Chlorodopsis areolata* H. M. Edw.

Family GRAPSIDAE.

Percnon planissimum (Herbst).

Plate V.

Cancer planissimus Herbst, Krabben u. Krebse, iii., 1804, pl. lix., fig. 3.

Liolophus planissimus Alcock, Journ. Asiat. Soc. Bengal, lxix., 1900, p. 439 (and syn.).

Percnon planissimum Grant and McCull., Proc. Linn. Soc., N.S. Wales, xxxii., 1907, p. 153.

Two males, here illustrated, were taken; these specimens are coloured as described by Alcock. The carapace of one example is 15·5 mm. in length and 13·7 mm. in breadth, that of the other is slightly smaller.

(3) Miers, Rep. Voy. "Challenger," xvii., 1886, p. 135.

REMARKS ON THE SYNONYMY OF CERTAIN TRISTOMATID TREMATODE GENERA.

By Professor T. Harvey Johnston, University, Adelaide.

[Read June 13, 1929.]

Whilst engaged in the study of some tristomatid trematodes, it became necessary to examine the validity of certain generic names which have become widely used and applied very differently by various authors. As the result seems to necessitate the sinking of some well-known names into synonymy, a sketch of the history of the genera involved appears advisable. These are *Phylline, Capsala, Phyllonella, Epibdella, Tristoma,* and *Benedenia.*

The confusion in regard to some of them has been referred to briefly by MacCallum (1927). In 1815 Oken used the name *Phylline* to designate a new genus which included *P. diodontis* Oken, *P. hippoglossi* Müller, and *Hirudo grossa* Müller, his diagnoses being republished by MacCallum (1927). This generic name was widely used by subsequent authors for parasites generally referred to as *Epibdella* spp., but it had been employed by Abildgaard in 1790 for a monozoic cestode, now known as *Caryophyllaeus,* and, therefore, not available for Oken's species.

The account and figures of the first-named species, *P. diodontis,* were based on those of La Martinière (1787, 1798) whose material was obtained from *Diodon* on the west coast of North America by the La Perouse Expedition. The description shows it to have been a tristomatid. Bosc, however, had previously (1811) given the name *Capsala martinieri* to the parasite, describing the genus as new.

The second, *P. hippoglossi,* which has commonly been regarded as the type of the genus, was based on *Hirudo hippoglossi* Müller (1776). The third, founded on *H. grossa* Müller (1788) is not a trematode, but a parasitic nemertine *(Malacobdella).*

In 1817 Cuvier, in his "Regne Animal," vol. 4, erected the genus *Tristoma,* describing and figuring one species, *T. coccineum.* Next year Lamarck (1818, 295) gave a summary of *Phylline,* mentioned the synonymy of *P. hippoglossi,* and stated his belief that the parasites were related to *Polystoma* instead of Annelids (leeches), where they had been allotted. He also referred to Blainville's manuscript name, *Entobdella,* for the genus, but retained Oken's *Phylline.* The reference was quoted erroneously by Braun (1889) as appearing in Lamarck's vol. i., p. 444, and subsequently (1890, 518) he indicated the genus with the date 1815 (when vol. i. appeared) as a synonym of *Epibdella.* Stiles and Hassall (1908, 251) credit *Entobdella* to Audouin 1828, whereas Agassiz (1845) and Scudder (1884), in their respective Nomenclatores Zoologici, attribute it to Blainville, but without mentioning a date. Sherborn, in his Index Animalium, gives the correct date (1818) for *Entobdella* (Blainville MS.) Lamarck. It was not mentioned by Rudolphi (1819), and has remained practically unrecognised since.

Rudolphi (1819, 427-30) mentioned the work of Oken and Cuvier, but accepted Cuvier's genus and described a new species, *T. maculatum* (p. 430), quoting in the list of synonyms, La Martiniere's account and figures, *Phylline diodontis* Oken, and *Capsala martinieri* Bosc. Since Cuvier's and Rudolphi's species are con-generic, *Capsala* Bosc obviously has priority over the better known

name *Tristoma*, and the family Tristomidae or Tristomatidae should be known as Capsalidae Baird, and the Tristomatoidea and Tristominae as Capsaloidea and Capsalinae, respectively. Poche's term (1926, 108) Tristomatides, substituted for Tristomeae Tasch., becomes Capsalides or Capsaleae.

In 1826 Baer subdivided Oken's genus into two sub-genera, *Tristoma* and *Nitzschia*, the latter being new, with *N. elegans* Baer as the only species. His three generic diagnoses were republished by Braun (1890, 527). The species was a renaming of *Hirudo sturionis* Abildg (1794), hence its correct name is *N. sturionis* (Abildg) Kroyer 1852. In the same year Nitzsch (1826) described *Tristoma elongatum* (= *Nitzschia sturionis*) and referred to *Capsala martinieri*.

In 1827 Blainville[1] erected *Epibdella* to receive *Phylline hippoglossi* (Müller). In 1840 Nordmann transferred the species of *Tristoma*, including *T. elongatum* N. to *Capsala*. In 1843 Rathke renamed Müller's species as *Tristoma hamatum*, including in its synonymy *Hirudo hippoglossi* Müller, *Phylline hippoglossi* Oken, and *Ertobdella hippoglossi* Blainville. Stiles and Hassall (1908) query the last-named generic name as having been intended for *Entobdella*.

In 1850 Diesing placed *Epibdella* as a synonym of *Phylline* and included under *P. hippoglossi*, Rathke's species along with others above-mentioned. He also ranked *Capsala* Bosc and *Phylline* Oken (in part) as synonyms of *Tristoma* and recognised *Nitzschia* as valid. The last-named three, together with certain other genera, were grouped in a family, Tricotylea. In 1853 Baird used the family name Capsalidae and restored *Capsala* Bosc, including *Phylline* Oken, *Tristoma* Cuvier and *Nitzschia* Baer as synonyms. He listed two species, *C. coccineum* (Cuv.) and *C. elongata* (Nitzsch), placing *Phylline hippoglossi* Oken and *Hirudo sturionis* Abildg under the latter as synonyms.

In 1856 van Beneden described and figured a new species of *Epibdella*, *E. sciaenae*, and mentioned the characters differentiating the genus from *Tristoma*, *viz.*, the large ventral sucker provided with hooks, but devoid of septa; the weakly-developed anterior suckers; and the undivided testes. In 1858 Diesing founded a new genus, *Benedenia*, to receive *Ep. sciaenae*, which he renamed *B. elegans* Dies.

In the same year van Beneden, who did not recognise the validity of the genus named in his honour, restored *sciaenae* to *Epibdella*, gave a further account of it and of *Ep. hippoglossi*, and published a generic diagnosis, which was reprinted by Braun (1890, 527) and Goto (1894, 233), both of whom then amended it. He did not differentiate between the two types of anterior suckers represented by the two species, and he included the presence of regularly-arranged papillae on the posterior sucker as a generic character. He also established the family Tristomidae (Tristomides) for *Epibdella*, *Tristoma* and *Udonella*. In 1863 both species of *Epibdella* were referred to by Beneden and Hesse, and the genus, together with *Nitzschia*, *Encotyllabe*, a new genus *Phyllonella* (type *P. soleae* Ben. and Hesse) and some others, was placed in Tristomidae, while *Udonella* was removed from it. The diagnosis and figures of *Phyllonella* were republished by Braun (1890), the chief difference separating it from *Epibdella* being the character of the anterior fixing organs which in the former are broad, thin, and folded, though serving as suckers.

In 1865 Johnston referred to *hippoglossi* under *Entobdella*. In 1877 Vogt gave an account of the reproductive system of *Phyllonella* and mentioned

(1) The date 1828 is usually quoted, but Sherborn (Index Animalium, pt. ix., 1926, p. 2169) recorded the genus as having been published by Blainville in Dict. Sci. Nat., vol. xlvii., 1827, p. 269, and in vol. lvii., 1828, p. 567.

that the genus was only slightly differentiated from *Epibdella*. Next year Taschenberg (1878) incorporated a large number of genera, including *Epibdella, Benedenia, Phyllonella, Encotyllabe, Nitzschia,* etc., under *Tristomum.* A similar attitude was expressed by him in the following year (1879) in his account of certain species of Tristoma, where he mentioned *Tristomum (Epibdella) hippoglossi* Oken, *T. (Epibdella) sciaenae* Ben., and *T. (Phyllonella) solea;* and quoted *Nitzschia elegans* Baer as *Tristomum elongatum* Nitzsch.

In 1888 Monticelli referred to the two species of *Epibdella* and to *Phyllonella.* He termed the anterior adhesive organ of the latter a "pseudoventosa" to emphasise its difference from that of *Epibdella.* A summary of earlier classifications of trematodes was given, and a protest made against Taschenberg's suppression of so many genera belonging to the Tristomidae. He accordingly restored *Nitzschia, Epibdella, Placunella, Phyllonella* and *Trochopus* to generic rank. He stated that Vogt's *Phyllonella solae (nec.* Ben. and Hesse) was identical in structure with *Ep. hippoglossi* as described by Beneden, and regarded *Benedenia* Diesing and *Phylline* Oken as synonyms of *Epibdella* (pp. 86-7 and footnote). He proposed a system of classification in which the family Tristomeae Taschenberg was subdivided into four sub-families: (1) Tristomidae Ben., containing *Nitzschia, Epibdella, Phyllonella, Trochopus, Placunella, Tristomum* and *Acanthocotyle;* (2) Encotyllabidae Montic. (with *Encotyllabe);* (3) Monocotylidae Tasch.; and (4) Udonellidae Ben. and Hesse. In his key to the genera (p. 97), the essential difference indicated between *Epibdella* and *Phyllonella* lay in the structure of the anterior adhesive organs.

In 1889 Linstow described *Phylline hendorffii.* About this time Braun (1889-1890) began to publish his work on the trematodes as part of Bronn's Tierreich. Figures of earlier authors relating to *Epibdella hippoglossi,* species of *Tristoma, Nitzschia, Phyllonella* and other genera were reproduced, and diagnoses of the sub-family Tristomidae and of its constituent genera were given (1890, 526-530). The generic characters regarded as separating *Epibdella* and *Phyllonella* were those already referred to. He rejected *Capsala* as being unidentifiable; regarded *Phylline* Oken as a synonym of *Epibdella* or of *Tristoma;* and quoted *Entobdella* Lamarck, 1815, as synonymous with *Epibdella;* while *Benedenia* was not recognised because erected without sufficient justification. Mention was also made that Monticelli (1890) regarded *Phyllonella soleae,* as described by Vogt, as a synonym of *Epibdella hippoglossi,* and hence *Phyllonella* might be identical with *Epibdella.*

In 1891 Monticelli gave an account and published figures of the three known species of *Epibdella (hippoglossi, sciaenae* and *hendorffii).* In 1894 Goto dealt with the anatomy of many heterocotylean trematodes, including two new species of *Epibdella, E. ishikawae* and *E. ovata.* He gave a diagnosis of the genus, amending that of Beneden, and transferred *Phylline hendorffii* to it, as Monticelli had done previously. He followed Braun in disregarding *Benedenia* as valid.

In 1895 Parona and Perugia described *Phylline monticellii* from *Mugil auratus.* Perrier (1897), in his synopsis of trematode genera, placed nine of them, including *Epibdella, Phyllonella, Encotyllabe, Nitzschia* and *Tristoma,* in the sub-family Tristominae, separating the first and second according to the character of the anterior adhesive organs. In 1898 St. Remy published a synopsis of the recently described species of *Epibdella* and various other monogenetic trematodes.

In 1899 Goto re-examined *E. hippoglossi* and transferred it to *Phyllonella,* since the anterior organs were found to mark the ventrolaterally folded outlets of the ducts of a single mass of dorsally-placed gland cells. He retained *Epibdella*

for related species possessing well-developed anterior suckers, and gave a brief account of *E. sciaenae,* pointing out that there was a single aperture for the common genital pore and the vagina, whereas in all other species of *Epibdella, Phyllonella* and *Tristoma* the two terminated separately.

In 1900 Linton published a brief account of *E. bumpusii* from a stingray, and mentioned that the anterior suckers were crossed by about twenty-two ribs. His figures indicate an elongated glandular rather than a circular muscular anterior adhesive organ. The vagina and common genital pore open together in this species. In the same year Pratt included *Tristoma, Nitzschia, Epibdella, Phyllonella,* and three other genera in Tristominae, excluding Encotyllabe (Encotyllabinae). He separated *Phyllonella* and *Epibdella* according to the structure of the anterior organs, Linton's species being retained in the latter genus. In the same year Scott (1900) gave a brief account of *E. hippoglossi* and *Phyllonella soleae,* publishing a figure of the latter and recording both as parasites of certain flatfish in Scottish waters.

In 1901 Monticelli described *E. (Phylline) diadema* from a ray and subdivided the genus into two subgenera, *Phylline* Oken and *Benedenia* Diesing, including in the former *E. hippoglossi* Müller, *E. soleae* Ben. and Hesse, *E. bumpusii* Linton, and *E. diadema* Montic.; while *E. sciaenae* Ben., *E. hendorffii* Linstow, *E. ovata* Goto, *E. ishikawae* Goto and *E. monticellii* Parona were assigned to *Epibdella (Benedenia).*

In 1902 Heath gave a detailed account of *E. squamula.* Next year Linstow (1903) described *E. producta* and followed Monticelli (1901) in retaining the same five species under *Epibdella (Benedenia).* In the same year Monticelli placed *Epibdella* in a new sub-family, Ancyrocotylinae, Tristomidae *(fide* Stiles and Hassall 1908, p. 252), and in 1904 he transferred Heath's species to the subgenus *Phylline.* Next year Odhner (1905) dealt with *E. hippoglossi* and pointed out that Monticelli's sub-genera *Phylline* and *Benedenia* were generically distinct, but that the former name, though older than *Epibdella,* must be reserved for *P. diodontis* Oken (= *Tristoma maculatum* Rud.) and was wrongly used by Diesing and Linstow. He, therefore, restricted the name *Epibdella* to the four species listed by Monticelli (1901) under *Phylline (hippoglossi, soleae, bumpusii,* and *diadema),* together with *E. squamula,* while the name *Benedenia* was utilized for the remainder. In 1906 he pointed out that *E. producta* Linstow was a synonym of *E. soleae.* In the same year Luhe described *E. (Benedenia) macrocolpa.* In 1907 Monticelli discussed the relationship of *Encotyllabe* to the other genera of Tristomidae, including *Epibdella;* and in 1908 the relationship of *Nitzschia* to these same genera. In 1915 Nicoll listed *E. hippoglossi* and *E. soleae* (Ancyrocotylinae) in his census of recorded British marine trematodes. In 1916 Cohn described *Phyllonella steingroveri* from an African fish.

In 1927 MacCallum reviewed, to some extent, the history of *Phylline, Epibdella* and *Phyllonella.* He retained the second and third of these names in place of *Phylline* and *Benedenia,* whose use Monticelli had previously suggested. To *Epibdella* were assigned *sciaenae, monticellii, ishikawae, ovata, macrocolpa, hendorffii,* and a new species, *E. melleni;* while under *Phyllonella* were placed *hippoglossi, soleae, diadema, bumpusii, squamula,* and *steingröveri.*

Summary.

From the foregoing it will be seen that *Capsala* Bosc should replace *Tristoma* Cuvier, with consequential changes in the family, sub-family and other group names to Capsalidae, Capsalinae, etc.; that *Entobdella* Blainville, with *Ent. hippoglossi* Müller as type, should be substituted for *Epibdella* (s. str.) Blainville; and that *Benedenia* Diesing, with *B. sciaenae* (Beneden) as type, is valid.

To *Entobdella* belong also *Ent. soleae, diadema, bumpusii, squamula,* and *steingröveri;* to *Benedenia, B. sciaenae, monticellii, ishikawae, ovata, macrocolpa, melleni* and *hendorffi.*

Subdivision of Entobdella and Benedenia.

The position of the vaginal aperture in relation to the common genital duct would permit a subdivision of each of these genera into subgenera. In *Ent. bumpusii* and *B. sciaenae* they open together. In *B. macrocolpa* the vagina opens beside the common genital pore, but travels posteriorly behind the testes and then forwards to the vitelline reservoir. In the remaining species the vagina, when present, opens elsewhere on the left side of the midline, but it is quite likely that in those cases where it has not been mentioned or has been reported as absent, that it is extremely short, opening to the exterior in the vicinity of the vitelline reservoir. We may then subdivide *Entobdella* into the following subgenera, *Entobdella* (s. str.) and *Parepibdella* (new subgenus), allotting the species as follows:—*Ent. (Ent.) hippoglossi* (type), *soleae, diadema, squamula,* and *steingröveri; Ent. (Parepibdella) bumpusii* as type of the subgenus. The species of *Benedenia* may be grouped into three subgenera: *Benedenia* (s. str.), for *B. (B.) sciaenae; Benedeniella,* n. subgen., for *B. (Benedeniella) macrocolpa* as type; and *Parabenedenia,* n. subgen., for the remaining species, *B. (P.) ovata, ishikawae, monticellii, melleni,* and *hendorffi,* with *B. (P.) ovata* as type.

The genus Macrophylla Kent.

In 1928 Miss Kent Hughes described a new genus *Macrophylla,* type *M. antarctica* Hughes, from a Victorian shark, *Mustelus antarcticus.* It was stated that its nearest ally was *Tristomum,* from which it was differentiated by possessing two compact testes; only five distinct radii in the disc; and glandular membranes at the anterior end, in place of suckers. The name was already preoccupied by *Macrophylla* Hope, 1837. *Macrophyllida* is suggested as a new name for it. A detailed account of the parasite will be published later.

The synonymy of the genera referred to in this paper may be tabulated thus:—

Entobdella (Blainville MS. in Lamarck, 1818); type, *E. hippoglossi* (Müller. 1776) Blainville, 1818.

Syns. *Capsala*—Baird, 1853 (in part).

Entobdella—Lamarck, 1818; Johnston, 1865.

Epibdella—Blainville, 1827; Beneden, 1856; Braun, 1890; Heath, 1902; Linstow, 1903; Linton, 1900; Monticelli, 1890, 1901, 1902; Nicoll, 1915; Odhner, 1905; Perrier, 1897; Pratt, 1900; Scott. 1901.

Epibdella (Phylline)—Monticelli, 1901.

Ertopdella—Rathke, 1843.

Hirudo—Müller, 1776 (in part).

Phylline—Oken, 1815 (in part), *nec.* Abildg, 1790; Lamarck, 1818; Diesing, 1850; Johnston, 1865; Linstow, 1889, 1903; Monticelli, 1901, 1904, 1905; Parona and Perugia, 1895; Sonsino, 1891.

Phyllonella—Beneden and Hesse, 1863; Braun, 1890; Goto, 1899; Monticelli, 1888; MacCallum, 1927; Perrier, 1897; Scott, 1901.

Tristomum—Taschenberg, 1878 (in part).

Tristomum (Epibdella)—Taschenberg, 1879 (in part).

Tristomum (Phyllonella)—Taschenberg, 1879.

Benedenia Dies., 1858; type, *B. sciaenae* (Ben., 1856) Linstow, 1903.

Syns. *Benedenia*—Monticelli, 1901; Odhner, 1905.
Epibdella—Beneden, 1856 (in part); Braun, 1890; Goto, 1894 (in part), 1899; MacCallum, 1927; Monticelli, 1888; Parona, 1896.
Epibdella (Benedenia)—Linstow, 1903; Luhe, 1906; Monticelli, 1901.
Phylline—Linstow, 1889 (in part).
Tristomum—Taschenberg, 1878, 1879 (in part).
Tristomum (Epibdella)—Taschenberg, 1879 (in part).

Nitzschia Baer, 1826; type, *N. sturionis* (Abildg, 1794), Kroyer, 1852.

Syns. *Capsala*—Baird, 1853 (in part); Nordmann, 1840 (in part).
Hirudo—Abildg, 1794 (in part).
Phylline—Oken, 1815 (in part).
Tristomum—Taschenberg, 1878, 1879 (in part).

Capsala Bosc, 1811; type *C. martinieri* Bosc, 1811.

Syns. *Capsala*—Blainville, 1828; Johnston, 1865; Nordmann, 1840 (in part).
Phylline—Oken, 1815 (in part).
Tristoma (um)—Baer, 1826; Beneden, 1858; Cuvier, 1817; Diesing, 1850; Rudolphi, 1819; Taschenberg, 1878 (in part), 1879 (in part); and of subsequent authors.

The species of *Capsala* at present known are:—*C. martinieri* Bosc; *biparasitica* (Goto); *coccinea* (Cuv.) Blainv.; *cornuta* (Verrill); *foliacea* (Goto); *interrupta* (Montic.); *laevis* (Verrill); *levinsini* (Montic.); *megacephala* (Linst.); *megacotyle* (Linst.); *molae* (Bl.) apparently = *C. cephala* Risso, 1826; *nozawae* (Goto); *onchidiocotyle* (Setti); *papillosa* (Dies.) Nordm.; *pelamydis* (Tasch.); *perugiai* (Setti); *sinuata* (Goto); *squali* (Bl.); and *uncinata* (Montic.).

Macrophyllida T. H. Johnston, 1929; type, *M. antarctica* (Hughes) Johnston.

Syn. *Macrophylla* Kent Hughes, 1928, *nec.* Hope, 1837.

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A GEOGRAPHICAL ENQUIRY INTO THE GROWTH, DISTRIBUTION, AND MOVEMENT OF POPULATION IN SOUTH AUSTRALIA, 1836-1927.

By Charles Fenner, D.Sc.

[Read July 11, 1929.]

Contents.

I.—INTRODUCTION.

In the course of an investigation into the physiography and economic geography of the valley of the Lower Murray River, the writer was led to note the manner in which various geographical factors influenced the growth and distribution of the population of that area. This, in turn, was found to be dependent upon, and correlated with, other considerations, which involved the whole of the State, so that it became necessary to extend the scope of the work in order to present a more extended discussion of the matter. In that way the present paper was developed, and it is the product of several years' study of the conditions discussed. That portion dealing with the Lower Murray Valley will not be specially stressed herein.

(a) *Periods dealt with.*—From the point of view of time it was thought desirable, and found possible, to extend the enquiry back to the foundation of the State (then a "province" or colony) in 1836, and to carry the investigations forward to the year 1927 and, in some cases, up to June, 1929. For the first few years of the State's history, the records are not complete, but the resources of the Government Statistician, and Annual Reports and Parliamentary Papers presented by other government departments, have made it possible to conduct intelligent enquiry throughout the whole of the ninety-two years involved.

Such an enquiry has been facilitated by the willing and generous co-operation and assistance given by various gentlemen, to whom the writer's indebtedness is acknowledged, namely: —Messrs. W. L. Johnston and H. L. Semmens (Statistical Department); Dr. L. Keith Ward and Mr. R. Lockhart Jack (Mines Department); Mr. W. T. McCoy (Director of Education); Professor Perkins and Mr. W. J. Spafford (Agricultural Department); Messrs. J. H. O. Eaton and J. T. Furner (Engineer-in-Chief's Department); Messrs. H. E. Bellamy and L. G. Temple (Hydraulic Engineer's Department); Mr. E. Bromley (Commonwealth Meteorological Department); Mr. T. E. Day, Surveyor-General; Messrs. C. B. Anderson and F. C. W. Christison (Railways Department); Mr. R. G. Peake (Harbours Board); Messrs. D. V. Fleming and R. A. Gibbins (Highways Department). The author is also indebted to Mr. B. S. Roach, for reading the proofs, and to the draughtsman, Mr. J. A. Tillett, for his painstaking work.

For purposes of convenience much of the evidence is presented in decennial periods, corresponding to the census terms, and for these sufficiently detailed information is not available prior to 1861. The paper will, therefore, deal generally with eight periods, each of which will be discussed separately, as follows:—

1st period	..	1836-1861	5th period	..	1892-1901
2nd period	..	1862-1871	6th period	..	1902-1911
3rd period	..	1872-1881	7th period	..	1912-1921
4th period	..	1882-1891	8th period	..	1922-1927

(b) *Area dealt with.*—From the point of view of the area to be considered, it was decided to include only the southern more settled portion of the State, which is, generally speaking, all that country that lies to the south of the line of 10-inch average annual rainfall. This practically corresponds to the portion known as "The Counties" (see fig. 1), and contains all the land that has been duly proclaimed as counties. This division corresponds with Griffith Taylor's "Adelaide Division" (*vide* "The Australian Environment," page 96).

The much more extensive area of the State lying to the north of this line has a rainfall that is not only low (under 10 inches per annum), but is also unreliable; there is a high evaporation, and though artesian water is available over large areas, the general conditions are unsatisfactory for anything more than a sparse

pastoral settlement; in some portions, both in the north-west and the north-east, even this is impossible. In spite of the fact that there is some mineral production under very difficult climatic conditions (Tarcoola, gold; Cooper Pedy, opal, etc.), and that there is a necessary railway population along both the East-West trans-continental line to Kalgoorlie (Western Australia) and the North-South line to Oodnadatta and Alice Springs (Central Australia), the decennial returns show a gradually decreasing population. The total number of persons living outside the counties is, on the average, less than five thousand, one person to every 60 square miles, compared with seven persons per square mile within the counties.

Except in a few cases where it was thought necessary to show the whole State, the maps and diagrams throughout this paper comprise only the area within the counties, of which the boundaries are shown.

(c) *Factors specially considered.*—A contemporary authority (Professor A. P. Brigham, "Geographical Review," April, 1929, p. 311) has defined geography as the study of the face of the earth and the distribution and adjustment of life thereon. In the present discussion, "the face of the earth" involves considera-tion of:—

(a) The geology and pedology (the rocks and the soils).
(b) The relief of the country (mountains and plains, river valleys and coastline, etc.).
(c) The climatic conditions (rainfall, temperature, sunshine, frosts, etc.).

While the "distribution and adjustment of life" leads us to enquire into:—

(a) Population (immigration and emigration, births and deaths, movement and distribution).
(b) Production (agricultural, pastoral, mineral, forest, manufactures).
(c) Transport and Communication (railways, harbours, rivers, roads, etc.).
(d) Water conservation (reservoirs, mains, artesian and sub-artesian supplies, etc.).
(e) Education, Research, and Invention (implements, manures, plants, animals, diseases of crops and stock, etc.).

(d) *Factors not specially considered.*—It is necessary to define, also, some of the important contributing factors that have *not* been specifically considered. These include:—

(a) The influence of the varying general policies of successive administrations.
(b) The strains and stresses of finance.
(c) The debatable problems of land tenure.
(d) The complex and difficult question of markets.

Of these matters it may be said that some students of human geography claim that finance and government are themselves largely controlled by natural geographical factors, such as good and bad seasons, transport and markets, and the contentment or discontent of the people (the last-named conditions being, in part, dependent on climates, soils, and seasons).

As in the case of finance and government, the land problem is a more purely human factor, largely governed by tradition, vested interests, and the wish of the people as expressed through their elected representatives; all three matters are left out of this discussion as far as possible. Some of these factors are more properly the domain of the historian and economist, notably those dealing with legislation, administration, taxation, and finance. Others, such as masculinity, nuptiality, fecundity, natality, and mortality, have been most capably dealt with by the statisticians (*vide* Sir George Knibbs, Appendix A, Volume I., Commonwealth Census, 1911).

The problem of markets is more purely geographical. The chief wealth of South Australia lies in agricultural and pastoral production. The most reliable world estimates regarding the area of land necessary for the maintenance of man, suggest that in a broad and general way each individual requires $2\frac{1}{2}$ acres for his upkeep (*vide* Sir Daniel Hall, "The Relation between Cultivated Area and Population," B.A.A.S., Oxford, 1926). This State, since the year 1909, has had upwards of ten acres under cultivation (including crops, fallow, and permanently sown grasses) for each individual in the State (see fig. 6). Theoretically speaking, therefore, on the basis of world production, South Australia should have more than three-quarters of its products available for export. This requirement demands reliable markets for our wheat, wool, wine, fruits, etc.

Up to the present time the chief markets for these products have been found in the great centres of population facing the North Atlantic Ocean. It is agreed that one of the most powerful of all geographical factors is space or distance. South Australia is far distant from her chief or potential markets, and there are many strong competitors in more favourable (*i.e.*, closer) positions. Improved and cheaper transport will alter these conditions, but not relatively, so far as competitors are concerned; though new and nearer markets may do so. There is no doubt of the enormous extent to which the factor of markets has pressed upon the growth and movement of population in this State, particularly in the Lower Murray Valley, but it has not been found possible to definitely include this factor in the maps and graphs accompanying this paper.

II.—SOUTH AUSTRALIA IN 1835.

(a) *Position, Size, etc.*—As may be seen from fig. 1, the State of South Australia is set within a square. That is to say, it extends over 12 degrees of longitude from west to east, and is bounded by the mathematical lines of 129° E. and 141° E. longitude. It likewise extends over 12 degrees from north to south, the northern boundary being latitude 26° S. The southern is thus the only natural boundary of the State, and it consists of an irregular and well-indented coastline extending in a south-easterly direction across the lower half of the square, from 32° to 38° S. latitude.

This indented, obliquely trending coastline has an enormously important bearing on the fertility and potentiality of the State, but it must be considered in conjunction with the equally important factor of latitude. The area north of latitude 32° lies within the influence of the drying trade winds, with summer monsoons. It is too far north to enjoy any noteworthy influence from the belt of cyclones and anti-cyclones ("lows" and "highs") that eddy across the southern portion of the continent, and too far south to receive an adequate contribution of summer monsoonal rains. Thus it comes about that the artificial dividing-line of latitude 32° corresponds roughly with a natural boundary, namely, the line of 10-inch annual average rainfall—one of the most potent geographical controls which we have to consider.

A second artificial boundary has grown up during the effort and experience of the past ninety years, and this is shown on fig. 1 as the northern boundary of the proclaimed areas, known as "The Counties." This irregular surveyed line corresponds, in a general way, with the line of 10-inch annual average rainfall, but is on the whole rather generous, and a good proportion of the area of the more northerly counties lies beyond the 10-inch isohyet. The size, shape, and areas of these two divisions are clearly set out in fig. 1, and need no further description for the present.

Abundant evidence is available to show that South Australia has reached a fairly definite northern limit of extension, so far as wheat production and general

cultivation is concerned, in the boundaries set by the proclaimed counties. One can but repeat and emphasise the opinion expressed by Dr. Keith Ward, in his Presidential Address to Section C. (A.A.A.S., Wellington, 1923, p. 281), that the correct policy for this State is to concentrate its attention on those portions

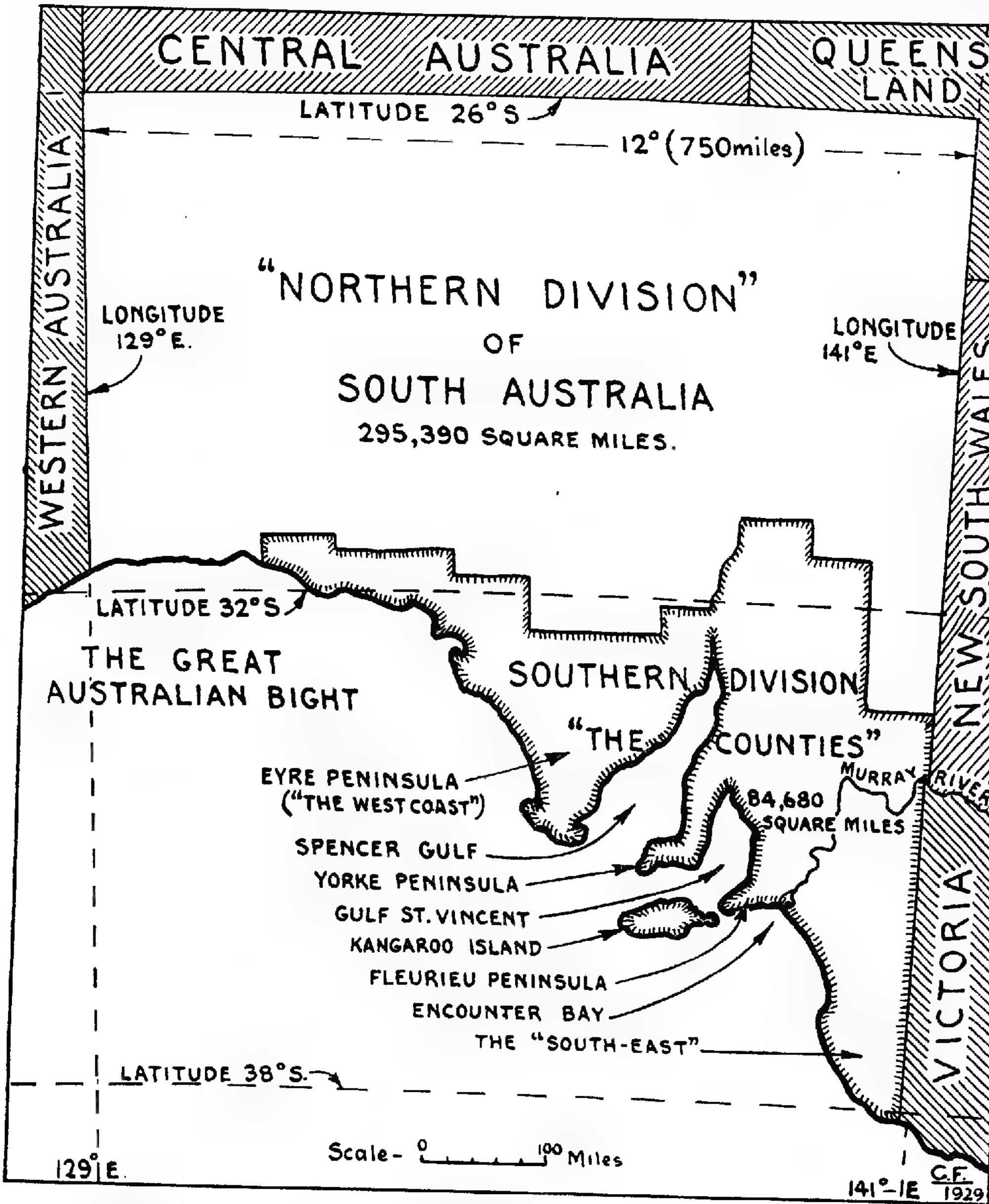


Fig. 1.
Map of South Australia, showing position, size, major divisions, etc., as detailed in Section II.

of the surveyed counties that are at present uncultivated. Both the pastoral and agricultural potentialities of South Australia lie mainly to the south of the 10-inch line of rainfall.

To these conditions came the Founders of South Australia in 1836. These pioneers had been moulded in a very different environment. Their geographical surroundings had been the agricultural, industrial, and commercial conditions of the well-watered islands of Britain, with a wealth of coal and iron, and a potent commercial position. Now they were transferred to an antipodean land where there was no commerce, no coal, and no other cheap power, and where the climatic conditions ranged from Mediterranean (olive, vine, and fig) in the south to desert in the north. Nor were these people pulled or driven by the urge of mineral discoveries, as was the case in several other colonies. The position presented a very complex problem of geographical adjustment.

(b) *Relief, Climate, etc.*—The relief and climatic conditions of the State have been well described in various publications by Howchin, Ward, Taylor, Bromley, and others, and as much as is specially pertinent to the discussion of the

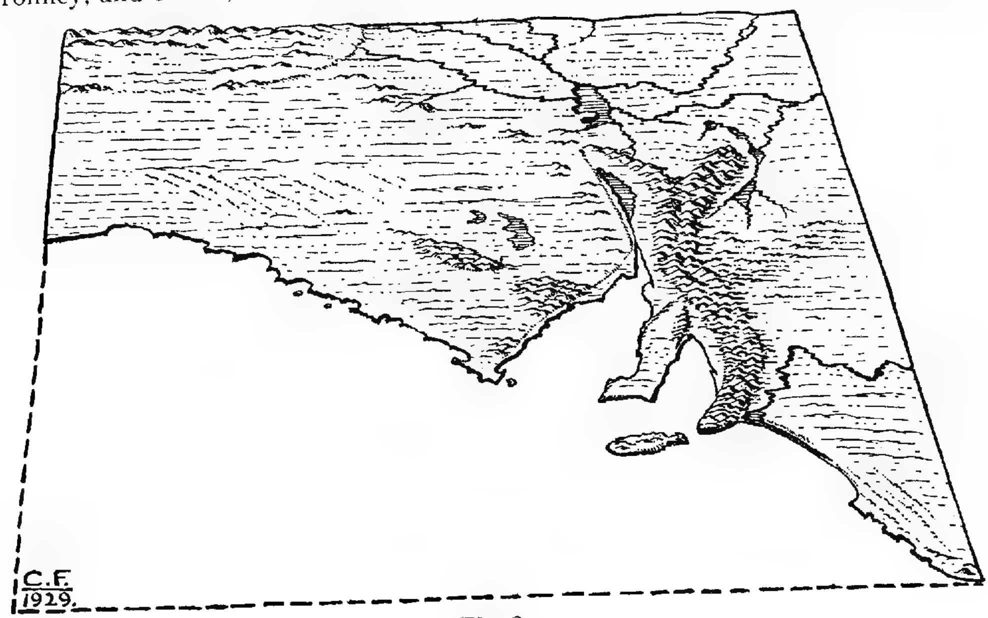


Fig. 2.

Sketch to indicate the general relief of South Australia. Almost the whole country consists of vast plains, stretching away to the Musgrave Ranges in the north-west, and to the Queensland border in the north-east. In the southern central portion is a structurally broken area, partly sunken and thus forming two great gulfs, and partly raised into the crescentic horsts of the Mount Lofty and Flinders Ranges. From the "Head of the Bight" to the south-eastern corner of the State, the irregular coastline is due to mighty subsidences towards the Jeffrey Deep in the ocean to the south. Thus this State lost much territory, but was opened up to the oceanic influences of the westerly winds, to its very great advantage.

distribution and movement of population will be described in the next section. The point to be stressed here is that the settlers of 1836 came to a land that was not only unknown to them so far as relief and climate were concerned, but it was practically unknown to the world. Flinders had placed the coastline on the map, Sturt had explored the Lower Murray, and Barker had viewed the Adelaide Plains from Mount Lofty. The founders of the State were unaware of the almost unbroken barrier that separated the Gulf Region from the Murray Valley.

The general lowness and level character of the country, apart from the Mount Lofty and Flinders Ranges, is shown in fig. 2. Nearly the whole State consists

of low plains, relieved by the central structural breaks of the Gulf Region and the Mount Lofty-Flinders Ranges, rising gently to the north-west as portion of the great stable plateau area of Western Australia, with the sunken basin of Lake Eyre to the north-east. The rising of the Central Highlands upset the previous drainage systems, as described by Howchin (A.A.A.S., Melbourne, 1913), and dammed back the north-eastern streams, as shown in fig. 2. As far as relief was concerned, transport and communication presented no problems except the barrier of the Mount Lofty Ranges, but very interesting influences on the development of towns, harbours, roads, and railways will be shown, in subsequent sections, to have followed on the coastal outline and the arrangements of hill, plain, and river.

Climatic conditions, with lack of rivers and fresh water supplies, made exploration and settlement difficult. These two factors led, on the one hand to the deeds of gallantry and endurance in exploration, that adorn the history of the State, and on the other hand to the development in South Australia of one of the most extensive systems of water supply and reticulation that has been developed by any country; this matter is dealt with in detail in a subsequent section.

(c) *Population.*—The population of this country in 1835 consisted of many thousands of aborigines, living an extremely primitive wandering life. The nomadic character of the tribes was, of course, more marked in the sparsely peopled north, for all desert peoples are of necessity wanderers—continual seekers of fresh supplies of food and water. The distribution of the early aboriginal population, as far as it can be discovered at this late date, was somewhat along the lines of the present-day distribution of the white population of the State, except that with us there is possibly a greater concentration in (a) the rich wheat areas, (b) mineral-producing localities, and (c) the capital city.

The aborigines, on the other hand, having come downwards from the north in the course of their "colonisation" of Australia, were much better acclimatized to arid conditions, and the dry northern areas may thus have been more densely populated, relatively, than is possible to us. As we learn from Sturt, Eyre, and others, the Lower Murray Valley was densely peopled with blacks, as were the sea-coast dune-lands wherever fresh water was available.

Contact with the new-comers has meant death to these primitive people, and the last report of the Protector of Aborigines (1928) gives 2,150 full-bloods (with an additional 1,550 half-castes) as the total aboriginal population of the State. It is significant that the final concentrations of this disappearing population are in the far-flung outposts of (a) the extreme north and north-west, (b) Koonibba (West Coast), (c) Point Pearce (Yorke Peninsula), and (d) Point McLeay (The Murray Mouth).

In addition to the blacks, there was in this area, in 1835, perhaps a score or so of white men. Some of these were temporary dwellers associated with the industries of sealing and whaling; others were semi-outcasts living in a very primitive fashion, emphasising the difficulties that attend the colonisation of a new and strange land. All of these white people were in the geographically favourable regions near the mouths of the central gulfs.

(d) *Native Animals and Plants.*—The story of the animals and plants of the State, as they were in 1835, constitutes a most fascinating chapter in zoology and botany. From the point of view of this paper, namely, the distribution and movement of population, the most extraordinary feature about them is the relatively small part which the native fauna and flora have played in the colonisation of the State.

The distribution of species and numbers, in both plants and animals, was influenced by the climatic conditions just as is the population distribution of to-day,

and the relative distribution-density appears to have been somewhat similar to that which we shall see later in the spot maps of population.

In the southern division the mallee (dwarf eucalypt) flora, with patches of sheoak *(Casuarina)* and tea-tree *(Melaleuca)*, was dominant on the plains, with *E. rostrata* along stream valleys and in the moister parts, and *E. capitellata* on the sandy-limestone plains of the south-east. On the highlands the larger eucalypts formed definite forests *(E. obliqua, capitellata, odorata, corynocalyx*, etc.). In the drier north the mallee gave way to mulga *(Acacia aneura)*, salt-bush *(Atriplex)*, and bluebush *(Kochia)*, with native pines *(Callitris)* on the hills, and *E. microtheca* along the creeks. The annual plants of the north have developed rapid life cycles, with quick flowering and seeding. Large areas in the north-west and, to a less extent, in the north-east are almost without vegetation, and are merely sand or gibber (stony) deserts.

The distribution of native animals was somewhat similar. Representatives of the wonderful group of the marsupials—specially adapted to arboreal habits, or to burrowing, or swimming, or flying (volplaning), or hopping—roamed over the whole State. Although there is no ground for believing that the coming of the dingo hastened the development of the hind-legs of the larger marsupials, as Kipling has playfully suggested in "Just-so Stories," there is reasonably good evidence that the development of hopping, as a means of rapid movement, is associated with the difficulties of obtaining food and water.

There are remarkable differences between the species of the more fertile southern division and the dry northern division, both in character and in numbers, while the (now extinct) huge, slow-moving, browsing diprotodon bears witness to the existence of more favourable climatic conditions in the not very distant geological past. Adaptation to dry conditions is shown also by the birds, as it is by the reptiles, amphibians, crustaceans, and insects. The frogs of the dry interior bury themselves for the summer, the ants store honey in swollen abdomens, the blind marsupial notoryctes lives wholly beneath the sand, and so on.

To the early settlers the trees were wood for fires, and the marsupials and larger birds (emus, wild turkey, pigeons), and a few fish were game. Beyond this, neither plants nor animals have exercised any very great influence on the development of the State. We have discovered that the hardwoods, when well grown, provide excellent timbers, but most of the larger trees of the country, down to the big-rooted (root-stock), slender trunked mallee, have found their chief value in providing what is to-day a diminishing supply of firewood.

Native timber has been used to some extent for house construction, but even in the earliest years of the State most of the timber so required was imported from Tasmania. South Australia is still, as it has always been, a country of stone and brick dwellings, and is unique among the States of the Commonwealth in this respect. This is a natural outcome of the operation of the geographical factors here described, and has its own set of economic influences.

Apart from some timber and plenty of firewood, with a notable contribution to medicinal oils (eucalyptus oil, etc.) the larger native vegetation has given little to man that is of commercial use, though much that is of sentimental value. The native herbage, however, although it is being displaced by introduced grasses and clovers, has been of enormous value for grazing purposes, and in many districts is preferred by stock.

In the northern division, the widespread, almost uniform mulga plant suite, with salt-bush, blue-bush, etc., provides good stock feed, and has been universally exploited for grazing purposes. In a region where the rainfall is so unreliable, the increase of flocks and herds during the "good years" leads to an inevitable over-stocking in the succeeding drought years, with consequent over-grazing, so

that in places this mantle of vegetation, that has taken untold centuries to produce, has been completely destroyed and has given place to wind-blown sand.

It will be seen that, on the whole, this "biological backwater" had little to offer civilized man in the way of plant and animal life, though, from the chemical standpoint, the plants are still largely uninvestigated. Man has had to bring with him his flocks and herds, his horses and poultry, his fruits and vegetables—to say nothing of the rabbits, starlings, weeds, snails, and other introduced animals and plants that are ousting the analogous native life as the whites have displaced the blacks.

III.—GEOGRAPHICAL CONTROLS.

Having completed the preliminary survey of the State and shown briefly the scope of the paper and the general condition of the area as it was taken over by the first colonists in 1836, it is necessary to give some further detailed description of the chief "geographical controls." In using this term, it may be emphasised that geography has ceased to be a mere descriptive account of a country—its rocks, relief, climate, etc.—and has become a study of cause and effect. This "effect" is chiefly the influence exerted by various natural conditions on the welfare and progress of man. The "cause" comprises those natural conditions of mountain and plain, soil and climate, under which man lives. It is not asserted that man—with his religion, government, production, commerce, invention—is wholly "controlled" by these geographical conditions. Nevertheless, the phrase "geographical controls" is justified by the powerfulness of the factors which we propose to investigate in so far as they have affected, in a broad way, the growth and movement of the population of the State.

(a) *Rocks, Minerals, and Soils.*—The geology of South Australia, up to the limit of our present knowledge, is well set out in Dr. Ward's Geological Map of South Australia (Mines Department, S. Austr., 1927), with his published notes thereon, and in Professor Howchin's "Geology of South Australia" (Adelaide, 1929). A few points require to be recapitulated and emphasised here. (See also Dr. L. Keith Ward's Presidential Address, Section C, A.A.A.S., Wellington, 1923.)

On account of the special climatic conditions of this State, the question of water supply constitutes one of the most important of its geological problems. It is a happy fact that the driest area of the northern division, *viz.*, the Lake Eyre region, is occupied by portion of a vast artesian basin, so that stock supplies from bores are available over a large part, making pastoral occupation and stock transport possible where it otherwise would not be. Smaller artesian and sub-artesian areas occur in the southern division; these also are well mapped, and the quality of their waters known. In other areas, also, the underground water supplies are fairly well known and utilized.

The direction of the railway to Oodnadatta was greatly influenced by the presence of the "mound springs" (natural artesian "bores") that have formed along the south-western border of the Great Artesian Basin. The distribution of the pastoral population of those north-eastern areas and the positions of stock routes have been mainly dependent on the positions of the artesian bores; the station "homesteads" are mostly established alongside the permanent "waterholes" that occur along the courses of the intermittent and meandrine streams that cross these vast plains.

From the point of view of geology and mineralogy, South Australian land surfaces may be summarised as consisting of one or other of two rock series: (1) Ancient rocks, mostly forming highlands, where metallic minerals may occur, and (2) Tertiary and recent rocks, mostly forming plains under 500 feet in elevation, where no metallic minerals occur. As a rough approximation, the relief map

(fig. 3a) may be regarded as a geological map. The shaded portions (highlands) may be taken to represent the highly indurated, folded, and intruded rocks of Palaeozoic and Pre-Cambrian ages, while the wide plains (unshaded) represent Jurassic, Cretaceous, and Miocene or younger limestones and sandstones, etc., fairly level-bedded, easily eroded, and covered almost everywhere by Recent wind-blown or stream-deposited materials.

In the ancient rocks gold occurs occasionally, and there have been several stimulating but commercially unsuccessful gold rushes, as Echunga (1852), Barossa (1858), Teetulpa (1886), and Tarcoola (1900). These have distinctly affected population movements, but not to so marked a degree as have the richer discoveries in other States, each of which led to an exodus from South Australia, notably the Victorian gold discoveries of the early fifties, the silver-lead find at Broken Hill in 1883, and the Western Australian goldfields in the early nineties. The chief metallic riches of South Australia have been copper (in the earlier years) and iron (in later years). The stimulus given by the copper discoveries was most notable, as will be seen later.

The progress of pastoral occupation is slow, as indicated by the maps and graphs accompanying this paper. Agricultural occupation, under the stimulus of good seasons or high prices, or both, may become quite rapid. But the impelling pull of mineral discoveries quite out-distances any other kind of population movement, on account of the concentrated and rapidly produced wealth.

This State's chief mineral product has been copper, and the following movements have left very definite marks on the population distribution:—

The discovery of copper at Kapunda in 1843.
The discovery of the Burra copper mine in 1845.
The discovery of Wallaroo and Moonta copper in 1860.

Even the fluctuations in the price of copper have affected the population maps of the counties, and of the State, while the cessation of work at Burra and Kapunda in 1877-78 was marked by emigration, not only from those localities but from the State. The closing of the Wallaroo-Moonta copper mines in 1923 is sufficiently close for most of us to remember the great difficulties that accompanied the absorption into other occupations of the population hitherto engaged in the copper-mining industry.

The existence of the rich silver-lead ores of Broken Hill (N.S.W.) has led to the development of Port Pirie, both as a port and a smelting depôt, and that town constitutes the second largest population centre in the State. The geographical controls were that the Port Pirie Creek, the ancient deserted mouth of the Broughton River, was the nearest port to the rich lodes of Broken Hill. Broken Hill was opened in 1884, and the railway connection was completed with Port Pirie in 1887. The chief metallic mineral being produced in South Australia at present is the iron ore of Iron Knob, which is exported to Newcastle to be smelted; under the influence of this "control" two towns have grown up in a region that would otherwise have supported no population whatever.

The tertiary and recent rocks of the plains contain no metallic minerals. In the arid north, at Cooper Pedy, opal occurs, and a township exists there of underground homes, one of the most remarkable cases of adaptation to geographical environment that modern civilization affords. The mineral wealth of the ancient rocks of the Northern Flinders Ranges, the Olary Spur, and elsewhere are not unexplored; nor are they well known. Deposits of ores of radium, gold, silver, copper, lead, etc., occur there, and these may at any time develop in importance. The report of the Director of Mines for the year 1928 shows that of the million pounds worth of minerals produced in that year, the greatest yield was from the

Eyre Peninsula (iron, £710,000; gypsum, £30,000; salt, £30,000). Next in importance comes the Central division, with a variety of products valued at £185,000. The Murray Mallee produces gypsum only, and there are no mineral products from the South-East. Outside the counties the gold of Tarcoola and the opal of Cooper Pedy are the most important mineral products. In the south, within the counties, the tertiary and recent deposits supply clays, cements, lime, barytes, salt, and gypsum, and there are also beds of lignite that have not yet been exploited. None of these have notably influenced the movements of population, with the exception of the salt and gypsum deposits of southern Yorke Peninsula, where communities exist wholly engaged in producing and transporting these minerals. The abundance, or otherwise, of building-stone, brick-clay, etc., has, of course, distinctly influenced the character and location of the various towns of the plains.

The chief wealth of this State, however, does not lie in minerals, but in wheat and wool. Over the wide plains of the southern division of the State, with light soils, reliable winter rains, and dry summer months for ripening and harvesting, the most important product is wheat. The factors that govern the production and marketing of the crops of this introduced plant are the most important of all the economic controls that affect South Australia.

South Australia, north of the latitude of Adelaide and up to the 10-inch isohyet, is pre-eminently a wheat-producing country (see fig. 10); elsewhere (and here also in part) the most important product is wool. The moister regions (those with a rainfall over 25 inches per annum), notably Kangaroo Island and the southern "toes" of the four peninsulas of the State—Eyre, Yorke, Fleurieu, and a portion of the South-East (fig. 36)—present peculiar problems, and have relatively sparse populations at the present day, 1929 (see fig. 7b), a fact that indicates that we have not yet solved their problems. The volcanic and peaty soils of the South-East have been more successfully exploited. I understand from Mr. Spafford, Deputy-Director of Agriculture, that the sowing of subterranean clover with "super" top-dressing of pastures indicates one successful method of more fully utilizing the somewhat incoherent ironstone soils of these lower peninsula areas.

The production factors that stand next in importance are the other crops grown:—The fruits, vines, lucerne, etc., along the Murray Valley; the hay of the Roseworthy-Kapunda districts; the barley of Yorke Peninsula; the fruits and vegetables of the southern ranges; the wines of Angaston, Reynella, and Clare; and the grasses and salt-bush of the north for sheep and cattle.

The manner in which climate and geography control the productions and the activities of man is clearly seen from a brief examination of the distinctly different types of farmers produced by the various geographical conditions that prevail in South Australia. Thus we have:—

(i.) The wheat farmer of the Lower and Middle North, with wide plains of deep alluvium and an opportune and reliable rainfall of from 10 inches to 20 inches.

(ii.) The wheat farmer of the mallee areas (North Central, Murray Mallee, West Coast, Yorke Peninsula, and the Adelaide Plains), with an originally scrub-covered sandy soil and a rainfall of 10 inches to 20 inches.

(iii.) The farmer and grazier on the limestone and volcanic areas and reclaimed peat lands of the South-East, with a 20-inch to 30-inch rainfall, where the chief drawback is excess of winter surface water owing to the undeveloped character of the natural drainage system.

(*iv.*) The irrigation farmer (citrus, vine, lucerne, etc.) of the Murray Valley (reclaimed swamps), with small holdings and abundant water supply—a supply dependent on the snow and rainfall of that distant highland belt that reaches from the Grampians to the Queensland border.

(*v.*) The grazier of the far-back north-eastern areas, with enormous holdings, largely dependent for supplies on the artesian wells and bores—a supply drawn from the abundant rains of the highlands of distant Queensland.

(*vi.*) The orchardist, vigneron, and gardener of the hills and valleys of the Mount Lofty Ranges, fighting against excessive soil erosion, with a good soil and rainfall, reliable wells, and a market close at hand.

(*vii.*) Last, but not least, the frontiersmen—the plucky settlers on the northern marginal lands of the wheat areas—facing the present-day difficulties and developing methods of overcoming them, pushing the boundary of settlement farther to the north, as the earlier settlers did before them.

In a country where agriculture is thus predominant, the soils are naturally of first importance. Much has been done in the way of classifying the soils in selected areas by the officers of the Agricultural Department. More modern methods of systematic soil survey, as developed in Europe, have recently been introduced, and are now being carried out on the Murray irrigation areas and elsewhere. (See also Prescott, Proc. Roy. Soc. S.A., vol. li., p. 287). But there is, as yet, no satisfactory soil map of the State available, so that for the time being the influence of this very important geographical control cannot be graphically demonstrated, except in an oblique way through the various soil-production maps and graphs that are illustrated or referred to herein.

(b) *Physiographic Features.*—The sketch shown as fig. 2 gives some idea of the general structural features of South Australia. These are more specifically shown in fig. 3 (after Ward), in which the more significant contour lines are indicated.

The great island mass of Australia may be divided into (a) a vast western portion, of very ancient rocks, with a high degree of geological stability, and (b) an eastern portion that has waxed and waned in size and has been raised and depressed, above and below sea-level, many times during its geological history. Between the relatively unstable eastern portion and the relatively stable western portion there appears to be a wide belt of structurally broken country, a sort of broad "shatter-belt," in which block-faulting and differential movement has been almost as marked a feature as it is in the eastern, uplifted marginal belt of the Australian Cordilleras.

This central disturbed belt may extend from the Gulf Region of South Australia up through the Eastern Musgrave and the MacDonnell Ranges (which Ward has shown to be block-faulted) towards the Wyndham district on the north. The fact that the Pre-Cambrian rocks extend in places well to the east beyond this belt, as shown by Ward (Proc. Roy. Geog. Soc., S.A., vol. xxviii.), does not necessarily affect this hypothesis.

To the south there have been great crustal subsidences that have formed the Jeffrey Deep, with subsidiary "falling away" of portions of southern Australia towards that deep, thus creating the Great Australian Bight, and giving South Australia the south-easterly trending coastline which leaves the land open to

receive the oceanic influences of the eastward moving eddies of "highs" and "lows," which so profoundly, and so favourably, influence our climatic conditions.

This central north-south belt of broken country is best known, and most marked, in its southern portion, and is another of the fortunate geographical circumstances in the structure of this State, for it has created the gulfs and ranges of the Gulf Region, and has contributed largely to the conditions that provide the

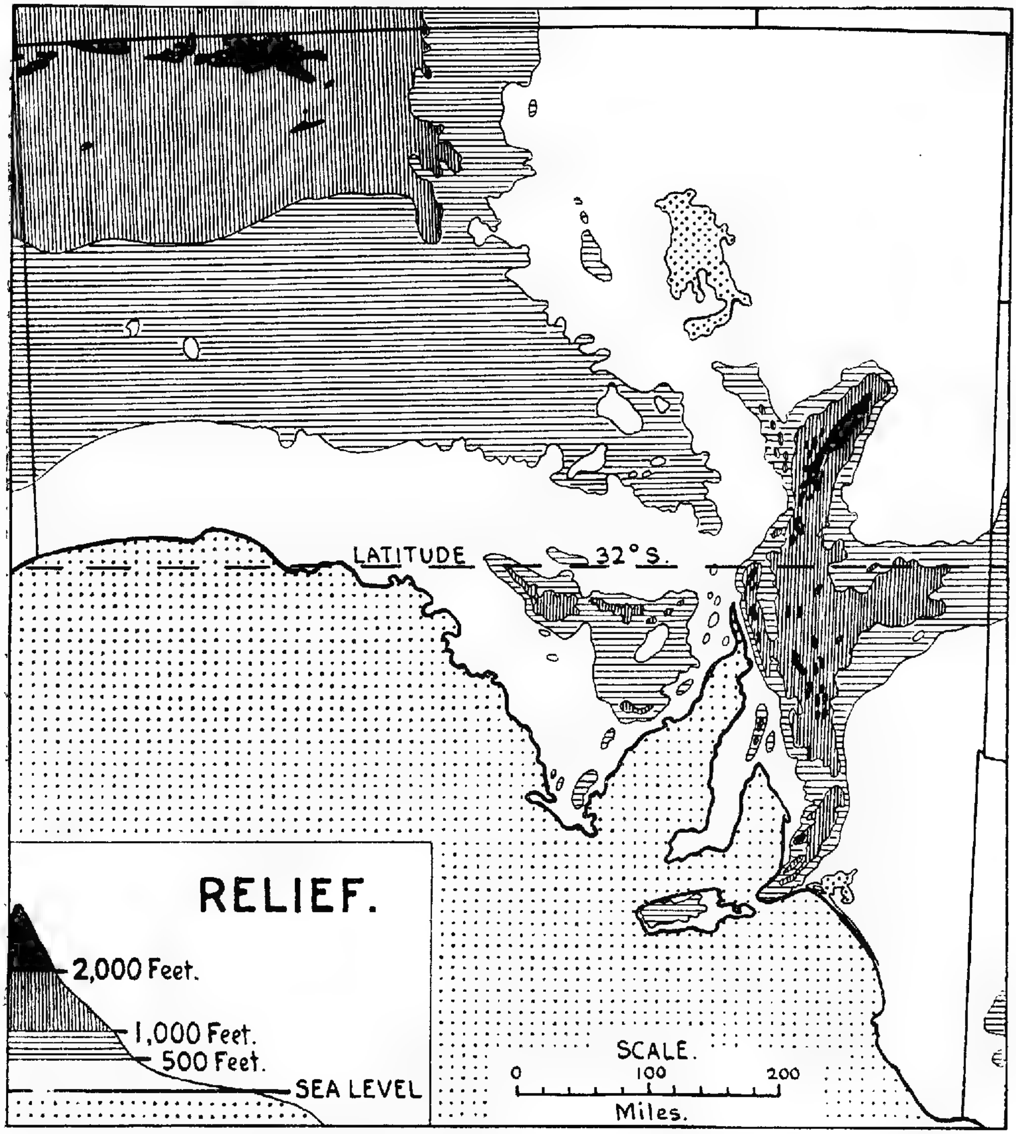


Fig. 3a.
Relief map of South Australia, after Ward, showing the chief contour lines, as elsewhere referred to in connection with transport, water supply, town sites, etc. Compare with fig. 2.

fertility and beauty, the variety and accessibility of the south-central portion of the State which is, and always will be, the most productive and the most important part of South Australia.

Since the greater part of the State consists of plains, the question of communication by road and rail has been a relatively simple matter in most cases. The general straightness of railway routes testifies to the ease of construction on the plains. This may be compared with the windings of the routes over the ranges. The chief barriers are the Mount Lofty Ranges, which are crossed in several places, and the Flinders Ranges, crossed twice, namely, through the low, winding Hookina Pass and the narrow and steep Pichi-Richi Pass.

The Mount Lofty Ranges have greatly influenced the spread of population in so many ways, directly and indirectly, that it is almost impossible to enumerate them, and indeed they are in most cases so obvious as to require no emphasis. The carrying of the main line from Adelaide to Melbourne and to the Lower Murray Valley over the highest part of the range has been dealt with in considerable detail by the writer in his paper on "Adelaide: South Australia" (Proc. Roy. Soc. S.A., vol. li., pp. 226-227).

In the lower portion of these ranges, from Gawler northward to Jamestown, and even to Carrieton, there is a peculiar repetition of a characteristic group of physiographic features, and this has had considerable influence on lines of communication, and on the distribution and movement of population. In these beautiful and fertile areas we find again and again a long, wide alluvial plain, longer than it is wide and extending north and south in its greater length; this fertile plain is bordered on either side by low, irregular ridges of older rocks, sparsely timbered or almost treeless. These ridges meet to the north and south in a more or less irregular way, forming an imperfect oval. The combination of scrubby highland and open plain, with the temperature and rainfall of this area, and the character of the soils, make it eminently suitable for agriculture, and here we have one of the richest areas in the State (see wheat map, fig. 10). These physiographic units extend northwards, one after another, and there are several series parallel to each other. A detailed contour map of this portion of the State would provide evidence of a topographical control of railway routes and population distribution almost as striking, in a smaller way, as the relation of the topography of Southern Pennsylvania to its population and distribution, as shown by Batschelet ("Geographical Review," July, 1927, p. 430).

(c) *General Climatic Conditions.*—The climatic conditions of South Australia are determined by:—

(i.) The latitude of the State, affecting the relation of the area to the belt of cyclones and anti-cyclones in the south, and to the trade winds and monsoons in the north.

(ii.) The area of the State, proximity or otherwise to the ocean, and the character of the coastline, as affecting the winds, rendering them drying or moisture-bearing, according to circumstances.

(iii.) The relief of the land, according as it directs the moisture-bearing winds upward and thus increases precipitation, or allows it to pass onward, growing warmer and more drying.

These climatic "controls" are most powerful, and they have already been frequently referred to in the preliminary descriptions which deal with native plants, animals, etc.; while the structural features, which in their turn assist in determining the climate, have also been mentioned. The map shown in fig. 3b will crystallize this information, and will enable the descriptions of population movement to be followed more intelligently.

Fig. 3b emphasises the division of the State into two portions, a northern one with less than 10-inch rainfall, and a southern one with from 10-40 inches of rainfall, according to elevation and latitude (for detailed accounts of the climate of

South Australia see "The Australian Environment," Griffith Taylor, pp. 87-104; and for full records of details of the weather from 1836-1917, see the 1918 publication of the Commonwealth Bureau of Meteorology, dealing with South Australia).

Into the northern dry area there extends a "promontory" of higher rainfall following the Flinders Ranges, but the country is rough, and though there is more pastoral occupation, with scattered mineral deposits, it is not so well peopled as

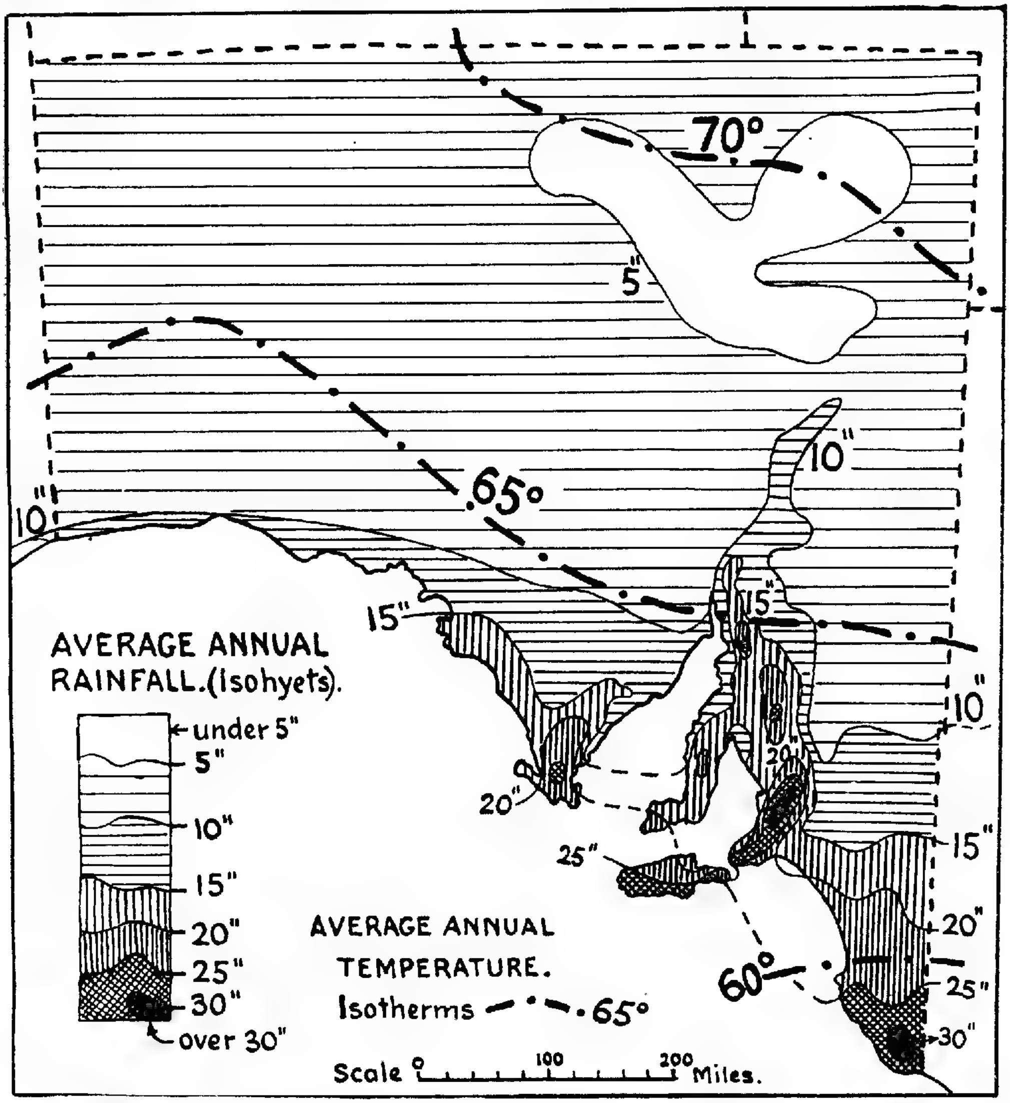


Fig. 3b.

Map of South Australia, showing the average annual rainfall and temperature (from Com. Met. Bureau records), as elsewhere referred to in dealing with these important geographic controls.

most of the 10-inch areas further south; remoteness and difficulty of transport are the chief contributing factors.

It may be noted that each peninsula that comes to the south—Eyre, Yorke, Fleurieu, and the "South-East"—bends the average isohyets further towards the

north, as do the highland areas. No further argument is needed to show that the uplifts and depressions that formed the highlands and sunklands of the Gulf Region played an immensely important part, not only in giving us accessibility and variety of country, but also in providing the much more important factor of increased rainfall, with the exhilaration that comes from climatic variety.

While the population distribution is a reflex of the rainfall, and the lowest rainfall corresponds with the most sparse population, the densest population is not in the region of highest rainfall. Indeed, the southern "toes" of the three central peninsulas, and of western Kangaroo Island, where there is an average annual rainfall of upwards of 20 inches, is quite sparsely populated. It would appear that for a climate with a long dry summer there is an optimum rainfall, as far as soil formation is concerned, and that an excess of rain in the wet winter months gives rise to incoherent "ironstone soils" and to other conditions unfavourable to agriculture. The wettest portion of the State (47 inches per annum) is on the high ranges east of Adelaide, a most important factor in the water supply of the metropolitan area.

The temperature conditions, as shown in fig. 3b, are very simple. South Australia receives an abundance of sunshine and warmth. There is little variation from north to south in the average annual temperature. The heat of summer is, with rare exceptions, dry and comfortable, even exhilarating; the winter climate, when the sun shines, has the characteristic Mediterranean charm. In Adelaide the average amount of direct sunshine during the *winter months* is over four hours per day.

The range of average temperature in the summer months is greater than in the winter months. In December, January, and February it rises from 65° F. in the south to 85° F. in the north. In the winter months, June, July, August, practically the whole of the State is between 50° F. and 60° F. With minor exceptions, the isotherms run from east to west and are controlled by latitude; the wind circulation and the highland relief are secondary influencing factors.

Just as there are disagreeable "heat waves" in summer that consist of successive days and nights of more than average heat, so are there "cold snaps" in winter; but snow is almost unknown and frosts are rare. There are, however, occasional regional frosts and hailstorms that amount almost to calamities in the amount of damage done, while the floods of winter and the bush fires and dust storms of summer must be counted among the occasional lesser unfavourable climatic conditions. The great influence exerted by recurring droughts will be shown in the next section.

(d) *The Incidence of Drought Years.*—In a consideration of the progress of South Australia from the geographical point of view, whether one specializes upon the increase or decrease of population, its dispersion or concentration, progress in railway construction, water conservation, land cultivation, soil production, manufactures, imports, exports, or any other factor, it becomes increasingly clear that the greatest of all of the antagonistic geographical controls influencing this State is that of a season, or a series of seasons, of low rainfall or "drought."

The matter is somewhat complicated by the fact that the pastoral salt-bush areas of the Far North, which depend on monsoonal rains, may have a good rainfall year, at the same time that the southern agricultural portion, which depends mainly on the cyclones and anti-cyclones of winter, may have a dry year. Another fact is that the natural climatic conditions of the most productive part of this State consist of (a) a long dry summer, that is, a "summer drought," and (b) a wet winter—the most important rain months being from April to November. Thus it happens that the normal summer drought does not always break in April or May, but it may even continue dry until November, and in one case (1888)

the general rains expected during the year did not come until the 1st January, 1889.

Reading through the weather notes of interested observers, where these have been preserved and published, we see that while "heavy rains" figure in the records almost every year, there is also scarcely a year in which drought conditions are not mentioned. Mention of droughts often refers to the months of April and May, when, as a general rule, the people of the State become somewhat anxious, and naturally inclined to stress any continuance of the normal summer drought.

For these reasons, even from the very complete records kindly made available by Mr. E. Bromley, the South Australian Divisional Meteorologist, it is difficult to decide which were the really disastrous drought years. In any case, owing to the natural half-year overlap of much statistical information, the dates given can only be correct to within six months either way of the actual incidence of the worst conditions.

It was most important, however, to have definite information regarding this climatic control, and in order to decide the actual drought years a variety of factors were considered, for all the years from 1836 onwards, namely:—

(a) A rainfall well below the average.
(b) Notable decrease in the numbers of sheep.
(c) Notable decrease in the numbers of cattle.
(d) Notable decrease in the total wheat yield.
(e) Notable decrease in average wheat yield.
(f) Other indications shown in the "Statistical Summary."

To this has been added the comments by observers previously referred to and, from a careful analysis of all these, it is concluded that the most severe drought periods were:—

1845—Apparently not general, but stressed by Sturt.

1851—Drought not general, but severe bush fires, including "Black Thursday."

1859-60—General very dry conditions.

1861—Classed by Sir Charles Todd as a drought year.

1865—Classed by Sir Charles Todd as a very bad drought year; disastrous results emphasised owing to the successive dryness of 1864-1865. These dry conditions were felt right through the later sixties.

1876—Classed by Sir Charles Todd as a very bad drought year.

1881-1891—This period shows undoubtedly the most severe and continuous dry conditions in the whole history of the State. Year by year there were low rainfalls, depleted flocks and herds, and very poor yields of wheat; it is noteworthy, as will be seen later, that this is correlated with the most severe period of population loss that has been recorded. The more severe drought years were 1881, 1885, 1888, and 1891.

1896—Coming to later periods, the 'nineties contained some dry years, centred around the year 1896, which may be classified as a very severe and long-continued drought, in which all agricultural and pastoral production received a notable setback.

1902—From 1900 onwards conditions greatly improved, though 1902 was a disastrous drought year.

1914—The period 1912-1921 commenced with three or four bad seasons, of which 1914 is marked in the memory of most of us as a disastrous drought year, much of the bad effect of which was felt in 1915.

From and including 1916 to 1926 the State was more free from drought conditions than at any previous period since the opening up of the outer country commenced, but dry conditions have followed.

A broad consideration of the way in which droughts affected the welfare of the State, shows that for the first twenty years they were scarcely noticeable. This is probably because at that time the settled areas of the State were in the regions of higher and more reliable rainfall. As the out-back country was opened up, the incidence of drought became more marked, culminating in the period from 1880 to 1903.

In the years from 1905 onward, partly owing to improved rainfall, but doubtless assisted by wiser methods and greater experience in appropriate agricultural methods, the incidence of drought has not been so marked as previously. Here we see in operation the effect of the human factor of education and research as practised by individuals and by Agricultural Research Institutes, and disseminated by means of the State Agricultural Department and its widespread and well-organised system of district bureaus.

(e) *The Cycles of Good Seasons.*—As a set-off to the story of the chief drought years, a careful and exhaustive effort was made to similarly mark the "exceptionally good years." Various factors prevented the exact assessment of this factor; a high rainfall season may be accompanied by red rust with a partial failure of the crops, as in 1867; or the apparent increases of the various selected prosperity factors may be but relative, and due to comparison with preceding droughts. In other cases, frosts played a part that could not be gauged; or the total rainfall may have been low but at the right time, with good crops.

The fact is, that in the settled portion of the State *most years are good years.* This is really, of course, a more important factor than the droughts, and has already been stressed in the reference to the high degree of rainfall reliability enjoyed by "The Counties" *(vide* Taylor's "Australian Environment," p. 20), amounting to over 80 per cent.

The area of this State is great, and generalizations thus become difficult. In the worst years of drought some localities enjoy above the average rainfall. Even in the disastrous year of 1902, the Eucla-Yalata strip was above the average and the Lake Eyre district had a better fall than usual. Similarly, the year's general rainfall may be good but inopportune, or, as is more often the case, average but opportune.

The Commonwealth Bureau of Meteorology publication entitled, "Results of Rainfall Observations in South Australia up to 1917," published 1918, shows, on the whole, however, and particularly in the graphs of sub-divisional rainfall, a remarkable similarity between the annual rainfall graphs of different regions. So far as monthly distribution is concerned, the rainfall of a dry year or a wet year on the West Coast is relatively similar to that on the Adelaide Plains or the Mount Lofty Ranges, though the actual annual total, of course, varies greatly from place to place, as shown in fig. 3b. These graphs and records also emphasise the fact that the drought years are irregularly recurrent, and are the exceptions. Satisfactory general rains and good seasons are the rule over the whole of the area south of the 10-inch isohyet.

Based on the records of the "Statistical Summary of South Australia, 1836-1928," the following factors were considered in the endeavour to assess the "exceptionally good years":—(a) Total rainfall, (b) Wheat season rainfall, (c) Total and average wheat yield, (d) Increase of flocks and herds, (e) Public Works, (f) Bank deposits, (g) Railway business, (h) Imports and exports, etc. The results of all these showed up certain exceptionally good years, such as 1916 and several of the following years up to 1925. It is more difficult to assess in this manner the good years prior to the 'sixties, but the early 'sixties were good, as were the following:—1867, 1871, 1873, 1875, 1878, 1880, 1887, 1889, 1890, 1893, 1894, 1903, 1906, 1908, 1909, and 1910.

The really good years depend on a cumulative effect, and occur in groups or cycles. The results of this particular enquiry regarding cycles of good and bad years were graphed and compared with the "Prosperity Graph" (figs. 22a and 22b), which was obtained in a quite different manner, as will be described. The correlation between the two graphs was high, approximately 80 per cent., and thus provided supporting evidence of the truth of the important curve of the pulsations of State prosperity and adversity which are set down in the final figure of this paper (see fig. 22).

IV.—HUMAN FACTORS CONCERNED.

(a) *The Land and the People.*—Ratzel, one of the foremost of geographers, has defined a "State" as: "A bit of soil and humanity." Brunhes, the author of "Human Geography," has gone one better in his definition: "A bit of soil, a bit of humanity, and a bit of water." We have already seen the extent to which this necessary "bit of water" has influenced population distribution in South Australia, and we shall see this still more effectively in later sections. We shall here endeavour to trace the method whereby the "bit of land" available in this State was placed under occupation by the "humanity" concerned.

The foundation of the State of South Australia is peculiar in that it was planned out beforehand, in a board-room on the other side of the world, with a land policy ready made, but with no really productive agricultural scheme or native products, and with no impelling attraction of gold "rushes" or other mineral discoveries. A careful study of the history of the early years, as told by Grenfell Price ("Discovery and Settlement of South Australia," Adelaide, 1924), and by the earlier diarists and historians of the "Province," coupled with the writer's own study of the graphs of production from 1836 to 1927, lead to the unwilling but inevitable conclusion that a proportion of the early settlers (figuratively speaking) sat down and waited for others to make money for them.

There was almost no proportional production for those early years, though there were doubtless many vigorous and earnest workers. Hence arose the famous "Crisis of 1841." Slowly, however, the matter righted itself. The groping people found their way; the idea of land-speculation gave way to the vigorous work of land-cultivation. Flocks and herds were established; the difficult labour of clearing land was undertaken, and by 1846 (after ten years of colonization) there was one acre per person under cultivation. This may be compared with the ten acres per person under cultivation in 1910, 64 years later.

(b) *The Opening-up of "The Counties."*—Reference has been made in the opening section, and illustrated in fig. 1, to the southern more settled portion of the State, known as "The Counties." This division includes about 85,000 square miles, which we may compare with the combined areas of England, Scotland, and Wales (88,000 square miles), or with the State of Victoria (87,000 square miles). This northern boundary line of the counties is most significant; it is the net result of the experience and effort of those people who have constituted the State of South Australia since its foundation; it is the human response to a very powerful geographical fact—that of diminishing rainfall.

The northern boundary of the counties coincides in a general way with the line of 10-inch annual rainfall (see fig. 3b), or with the line of 8-inch winter rainfall (see fig. 10). It is worthy of note, and is an indication of the courage and optimism of our people, that this man-made boundary does not shrink back from the 10-inch rainfall line, but boldly pushes beyond it into the drier areas to the northward.

The following table gives the total area of each county, the area still unoccupied in 1927, and the relative populations in 1861 and 1921:—

AREAS AND POPULATIONS OF COUNTIES.

Name of County and Division.	Date of Proclamation.	Total Area in Acres.	Area Unoccupied, 1927.	Population, 1861.	Population, 1921 Census.
		Acres.	Acres.	Persons.	Persons.
I. CENTRAL DIVISION—					
Adelaide	1842	730,000	18,000	66,238	278,508
Carnarvon	1874	1,075,000	575,000	175	1,347
Eyre	1842	906,000	39,000	1,097	5,751
Fergusson	1869	1,189,000	54,000	—	9,626
Gawler	1842	594,000	20,000	3,784	12,786
Hindmarsh	1842	656,000	50,000	15,502	12,365
Light	1842	537,000	6,000	14,980	15,288
Sturt	1842	850,000	97,000	4,546	10,075
II. LOWER NORTH DIVISION—					
Burra	1851	1,331,000	65,000	5,483	3,882
Daly	1862	1,061,000	64,000	1,232	20,682
Kimberley	1871	888,000	5,000	—	1,492
Stanley	1842	1,007,000	26,000	4,835	11,328
Victoria	1857	916,000	40,000	538	21,042
III. UPPER NORTH DIVISION—					
Blachford	1877	726,000	33,000	—	607
Dalhousie	1871	787,000	23,000	—	6,445
Derby	1877	950,000	136,000	—	—
Frome	1851	965,000	34,000	987	9,245
Granville	1876	748,000	33,000	—	567
Hanson	1877	806,000	92,000	—	496
Herbert	1877	980,000	36,000	—	652
Lytton	1877	884,000	75,000	—	—
Newcastle	1876	781,000	39,000	—	2,497
Taunton	1877	1,374,000	37,000	—	224
IV. SOUTH-EASTERN DIVISION—					
Buckingham	1869	1,146,000	149,000	—	2,354
Cardwell	1864	1,069,000	103,000	—	222
Grey	1846	1,308,000	115,000	3,337	15,186
MacDonnell	1857	1,182,000	63,000	652	1,281
Robe	1846	1,256,000	76,000	1,477	3,758
V. WESTERN DIVISION—					
Bosanquet	1913	1,280,000	155,000	—	72
Buxton	1896	1,155,000	628,000	—	435
Dufferin	1889	1,679,000	936,000	—	452
Flinders	1842	1,177,000	66,000	758	4,626
Hopetoun	1892	1,536,000	654,000	—	328
Jervois	1878	2,368,000	1,197,000	—	3,110
Kintore	1890	908,000	320,000	—	364
Le Hunte	1908	1,247,000	748,000	—	724
Manchester	1891	1,235,000	143,000	—	1,107
Musgrave	1876	1,568,000	403,000	—	1,121
Robinson	1883	1,711,000	346,000	—	1,538
Way	1889	1,670,000	990,000	—	1,400
York	1895	845,000	212,000	—	939
VI. MURRAY MALLEE DIVISION—					
Albert	1860	1,404,000	211,000	69	4,785
Alfred	1869	961,000	89,000	—	3,508
Buccleuch	1893	1,491,000	228,000	—	2,154
Chandos	1893	1,677,000	405,000	—	2,877
Hamley	1869	1,404,000	527,000	—	6,630
Russell	1842	847,000	171,000	257	3,366
Young	1860	1,329,000	136,000	52	357
		54,284,000	10,668,000	126,000	487,600

The general arrangement of the counties is shown in fig. 4. The first proclamation of these surveyed areas was made in 1842, about which time the population was beginning to spread well away from the Adelaide Plains, but still in areas of high and reliable rainfall.

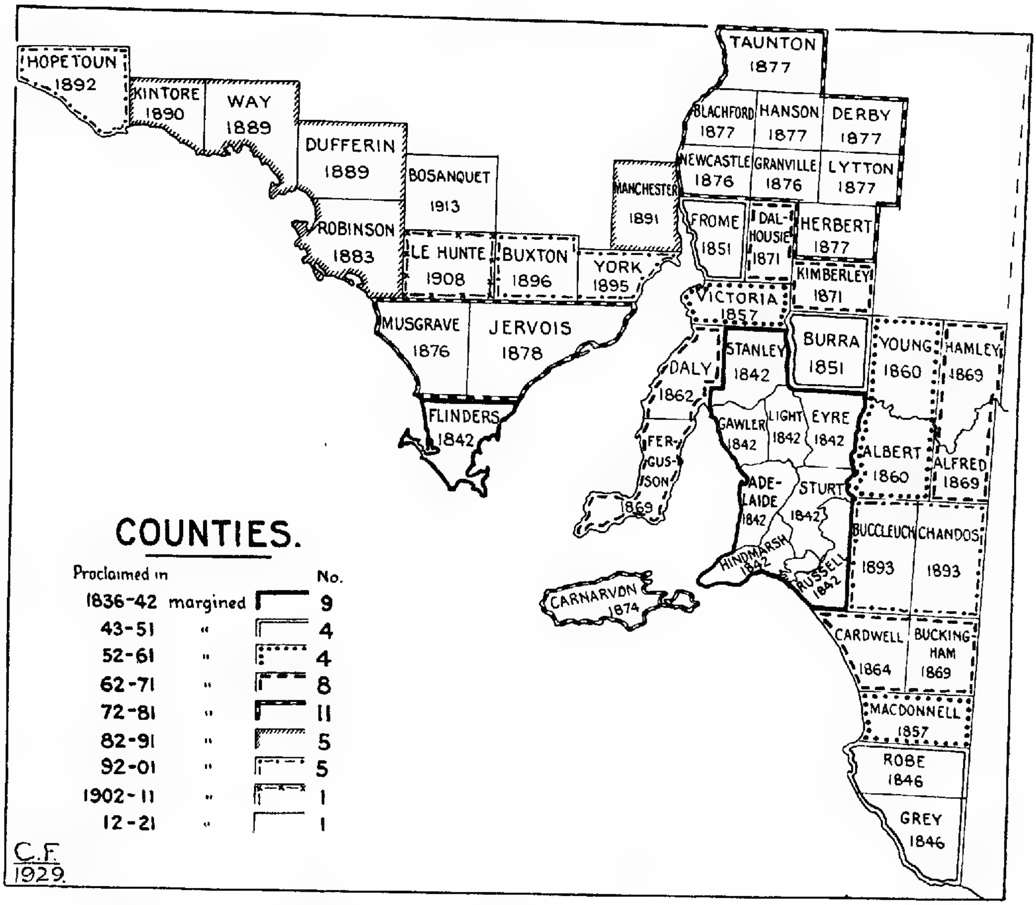


Fig. 4.
Plan of the Counties, showing the position and size of each county and the date of proclamation. It will be seen from the context that the order in which these lands have been opened up has been mainly one of decreasing rainfall, and that the northern boundary is strictly limited by rainfall conditions. (See figs. 3b and 10).

Gradually thereafter, with special bursts of activity in 1869-79 and in 1889-97, the whole of the counties were proclaimed. The order is of interest, as follows:—

1842—Adelaide, Gawler, Light, Sturt, Hindmarsh, Russell, Stanley, Grey, Eyre, Flinders.
1846—The wetter South-East counties, Grey and Robe.
1851—Burra, Frome.
1857—Victoria, MacDonnell.
1860—Albert, Young.
1862—Daly.
1864—Cardwell.
1869—Alfred, Hamley, Fergusson Buckingham.
1871—Kimberley, Dalhousie.
1874—Carnarvon (Kangaroo Island).
1876—Musgrave, Granville, Newcastle.
1877—Blachford, Derby, Hanson, Herbert, Lytton, Taunton.
1878—Jervois.
1883—Robinson.
1889—Dufferin, Way.
1890—Kintore.
1891—Manchester.
1892—Hopetoun.
1893—Buccleuch, Chandos.
1895—York.
1896—Buxton.
1908—Le Hunte.
1913—Bosanquet.

It will be noted that for the past 40 years little has been done in the opening up of fresh counties, and for over 16 years nothing at all. Actually we have reached the limit, as far as the present stage of agricultural practice is concerned. It may even be said that we have gone beyond it. In a burst of optimism in the late 'seventies, perhaps inspired by the 10-million bushel harvest of 1875-6, several northern counties were opened up. They included Lytton, Derby, and Taunton; Manchester was proclaimed in 1901. These four counties are quite outside (north of) the 8-inch winter rainfall line (see fig. 10), and although it is now over 50 years since three of them were proclaimed, the latest (1929) official harvest estimates show no return whatever for these counties. Some of them are now disregarded by the Government Statistician in his official county returns.

The suggestion arising from a consideration of these facts is one that has been frequently put forward, but is more often lost sight of. It is that the productive land of South Australia is severely limited by the rainfall, and lies within "The Counties"; it is on this area that we should concentrate in our endeavours to increase our agricultural and pastoral production. As Griffith Taylor has already emphasised (A.A.A.S., Presidential Address, Section E, Wellington, 1923):—"Lord Bryce has pointed out that governments such as ours are not leasing *land*, but *rainfall*, to the settlers."

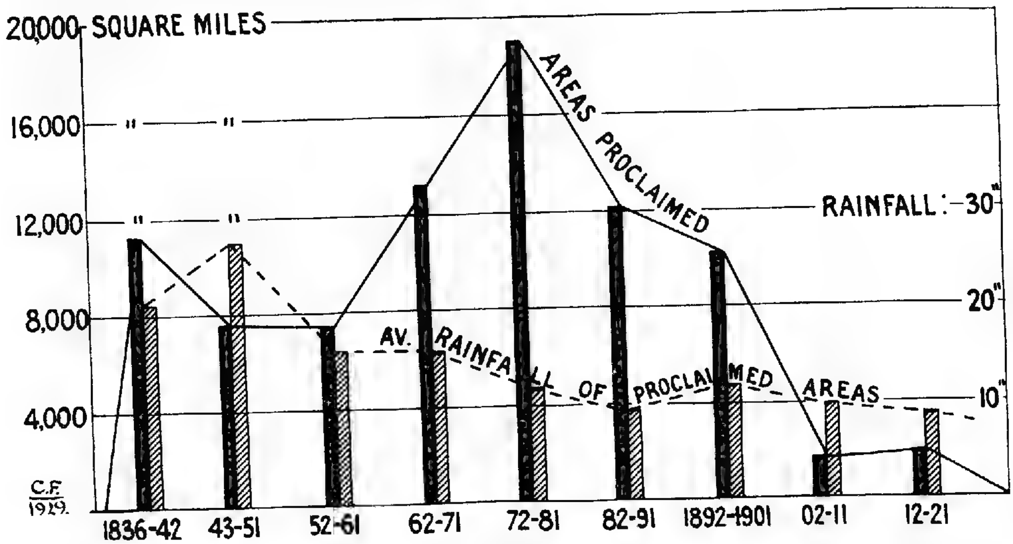


Fig. 5.

Graph showing the progressive opening-up of county areas in square miles, in decennial periods, with the average annual rainfall of the area proclaimed in each case. It will be seen that for the past 30 years no new land with more than 10 inches of average annual rainfall has been proclaimed. As shown in the preceding table, however, large areas of good rainfall land within the counties still remain undeveloped.

This important pronouncement by Lord Bryce needs no further emphasis. Every map of this State supports the idea. Fig. 5 shows that the first counties (1842) had a rainfall above 20 inches. The second decennial period included those counties of the more moist South-East (Mount Gambier district), and the average rainfall was nearer 30 inches. The areas later opened for settlement showed that we were progressing northward, north-east (Murray Mallee), and westward (Eyre Peninsula) into areas of lower and lower rainfall. Since the opening of this century no new counties with more than a 10-inch rainfall have been

proclaimed, and none remain to be proclaimed. We have reached the limit of general northerly advance, and should now concentrate on the areas we have won.

From the 'sixties to the early 'eighties there was a period of general prosperity in South Australia, broken by the depression of 1867-1872, when copper prices and wheat yields were low. It was then that the greatest forward movement was made in extending the counties. But agricultural practice, water conservation, and railway construction had not kept pace with the proclamation of counties. From 1884 on into the new century (1904) there was a series of more or less adverse years, and since 1900 only two outback counties, Bosanquet and Le Hunte, have been proclaimed.

The facts set out in the plan of the counties (fig. 4) and the graphs of their dates of proclamation, areas, and rainfall (fig. 5) present indisputable evidence of the controlling factor of rainfall. In earlier years a general northern limit was set by the well-known "Goyder's line." This line, which was mainly based on vegetation (an "ecological isopleth"), was a reliable guide and a remarkable piece of work on the part of Surveyor-General Goyder. Now, however, with a knowledge based on many years of accumulated rainfall records, and with an agricultural technique that has carried production well beyond this line, the latter becomes an object of purely historical interest. It has been displaced by the more northerly line of 10-inch average annual rainfall (fig. 3b), or still more surely by the line of 8-inch April-November rain (see fig. 10).

(c) *The General Distribution of Population.*—The general distribution of the population of the State during its earlier years is most difficult to arrive at with any degree of certainty. The first really reliable records that could be obtained dated from the census of 1861, and "spot maps" that are reasonably correct within the limits of the dot-unit selected are presented for each decennial period from 1861 to 1927 (see figs. 7a, 7b, 19a and b, 20a and b, 21a and b).

The selection of the dot-unit was not a simple matter. Various numbers were tried, and it was found that one dot for each 100 people served the purpose most successfully. For country areas the smaller the number selected the more accurate the map, provided that detailed data are available. In many American population maps every 25 persons are represented by one dot. For cities, or even for smaller townships, dots representing such small numbers of people cease to have much value; many devices have been adopted to overcome this. After various experiments, and in view of the scale of the maps and the character of the figures available, the unit of 100 persons per dot was adopted, with clusters to represent the townships and other "islets" of country population, and blots to represent the larger towns; the detailed distribution of the population of the metropolitan area has already been shown by the writer (Proc. Roy. Soc. S.A., vol. li., 1927, p. 253).

The data drawn upon for the population distribution becomes more and more vague as we go backward in time, and for the period prior to the publication of State directories it was necessary to utilize all varieties of information from police, church, post office, and other lists, and from old newspapers and advertisements. The source *in all cases*, however, as far as counties as a whole are concerned, is the reliable one of census returns. In addition, the statistics of corporations, country towns, and directory information were utilized, and the generous assistance of the Government Statistician (Mr. W. L. Johnston) and the Librarian of the Public Library (Mr. H. R. Purnell) have made it possible to locate the "dots" with a reasonably high degree of reliability.

The general graph of the population growth shows a gradual progress from 1836 to the present day, but there were actual decreases in several years, in part due to migration following bad seasons, in part owing to the lure of mining fields in other States, and in one major case (1915-1916) due to the Great War. The decrease of 1885-6-8 was largely owing to the Broken Hill (N.S.W.) mineral

discoveries; that of 1902 was almost wholly due to the disastrous drought of that date.

The general trend of this graph calls for no special comment. It shows a gradual and healthy growth, with a gradient characteristic of prosperous new lands. It has a grade comparable with that of Australia as a whole, and with that of the United States of America; a much more rapid growth than is shown by the older countries of the world, particularly those of Europe, where some population gradients are almost level or even descending.

The graph of "cultivated land" is compiled from the "Statistical Summary" of the State, and includes all the land under crop, fallow, or sown with permanent grasses. Little was done for the first ten years, thereafter there was accelerated progress, largely due to the adoption of additional mechanical assistance on the

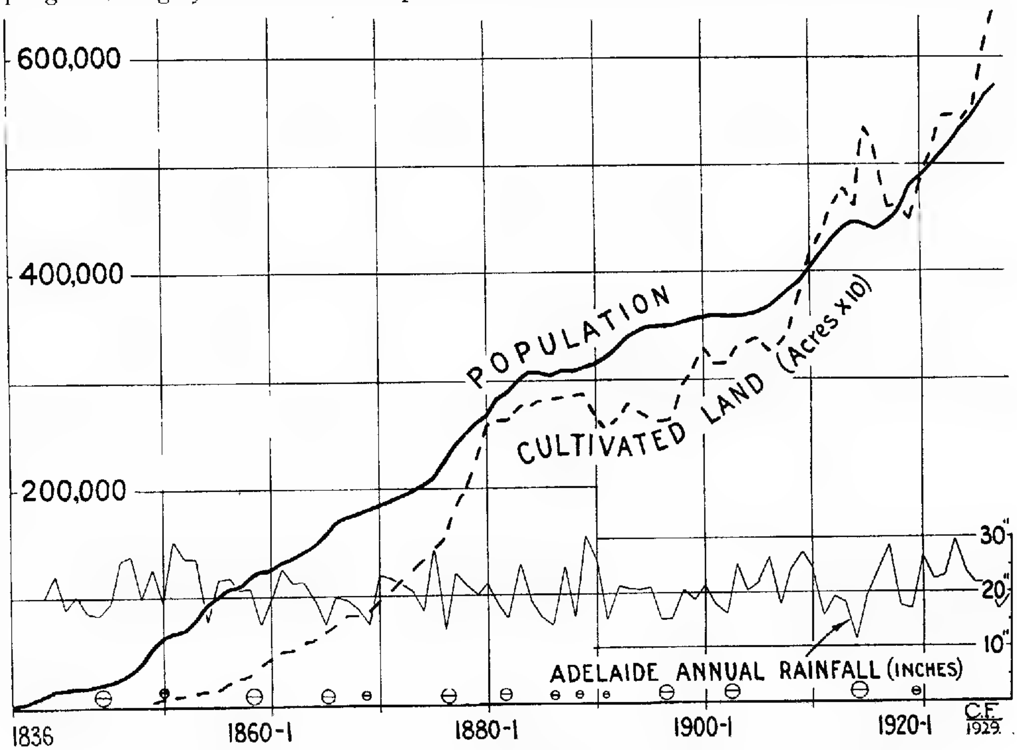


Fig. 6.

Graph showing the population growth from the birth of the State (1836) to 1927. With this is graphed the progressive acreage of cultivated land (unit: 10 acres). By 1910 there were 10 acres under cultivation for each person in the State, and this proportion has since increased. The annual rainfall at Adelaide is also shown, and its bearing, both on population growth and cultivated area, may be noted. The barred circles at the foot of the figure represent dry seasons.

farm. The effect of dry seasons is noticeable, and apart from the abnormal conditions of the war years there is an interesting and natural causal relation between the three lines shown on fig. 6.

In fig. 7 we see the population of the State after 25 years of effort. The great bulk of the population was, as at present, in the pleasant and fertile central regions of the Spencer-Vincent Sunkland, and on the adjacent ranges, where good soils and reliable rains prevail. The wheat production in that year (1861) reached 3½ million bushels, with a total population of 130,000 people.

The "West Coast" (Eyre's Peninsula) was almost untouched, the northern districts had not been exploited, Yorke Peninsula, The Murray Valley, Kangaroo Island, and the Murray Mallee remained practically untouched; there was good progress in the wetter districts of the South-East, particularly around Mount Gambier itself, and at Robe and Naracoorte. In those days travel and transport were slow and cumbersome; good roads were rare; there was a railway from Port Adelaide to Adelaide, and a tramway from Goolwa to Port Elliot. The only purely inland railway was that to Kapunda (copper). The county of Adelaide contained more than half the people of the State.

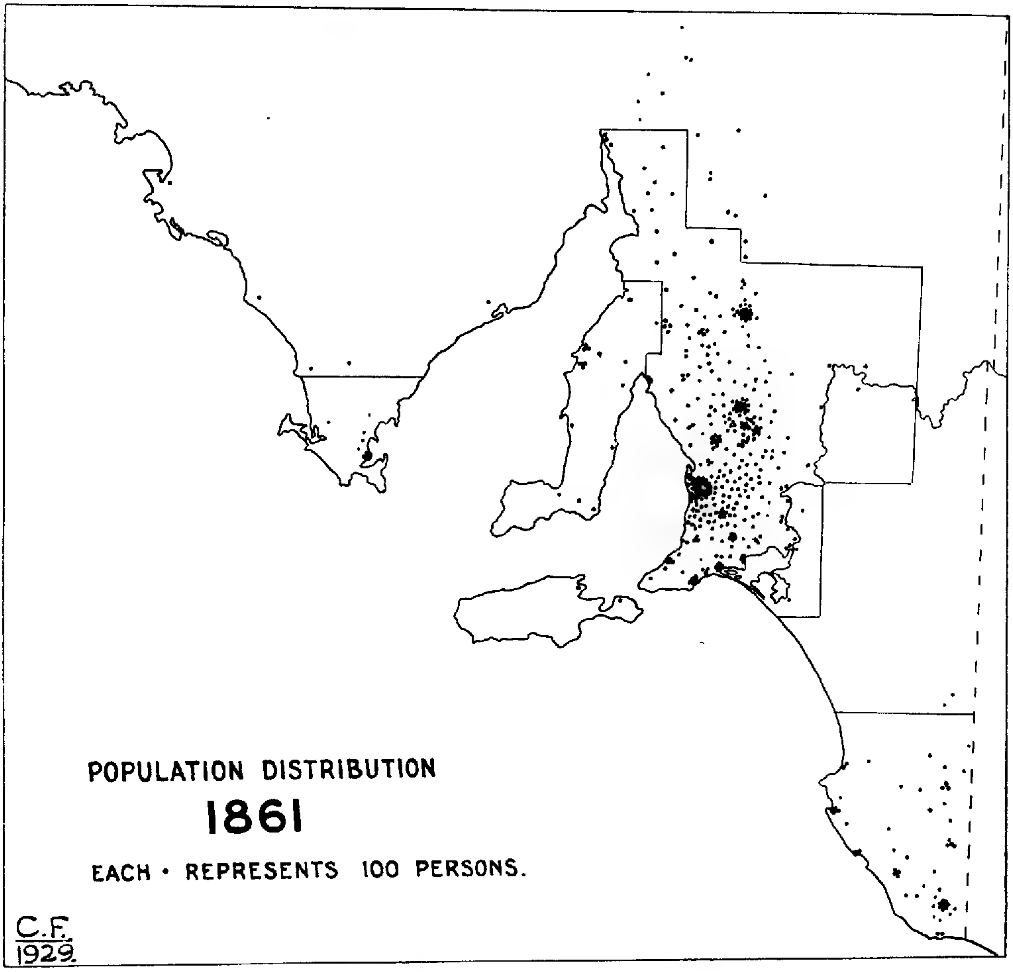


Fig. 7a.
Spot map of the population of South Australia in 1861, showing the growth and dispersion that had taken place during the first 25 years of the State's existence. The county boundaries of that date are also shown.

There were no country reservoirs, and Adelaide itself was yet to receive its first reticulation of both water and gas. The State had discovered its value as a wheat producer (3,576,000 bushels), as a wool area (13,000,000 lbs.); there were three million sheep and 260 thousand cattle. Copper, however, played a considerable part in taking the population away from the cities, in the powerful way characteristic of the mineral industry. Kapunda and Burra were notable copper

producers, and Wallaroo had just been discovered; apart from the agricultural centres of Gawler and Mount Gambier, the four chief "islets" of population in the country were at Kapunda, Burra, Wallaroo, and the "copper port" of Port Wakefield.

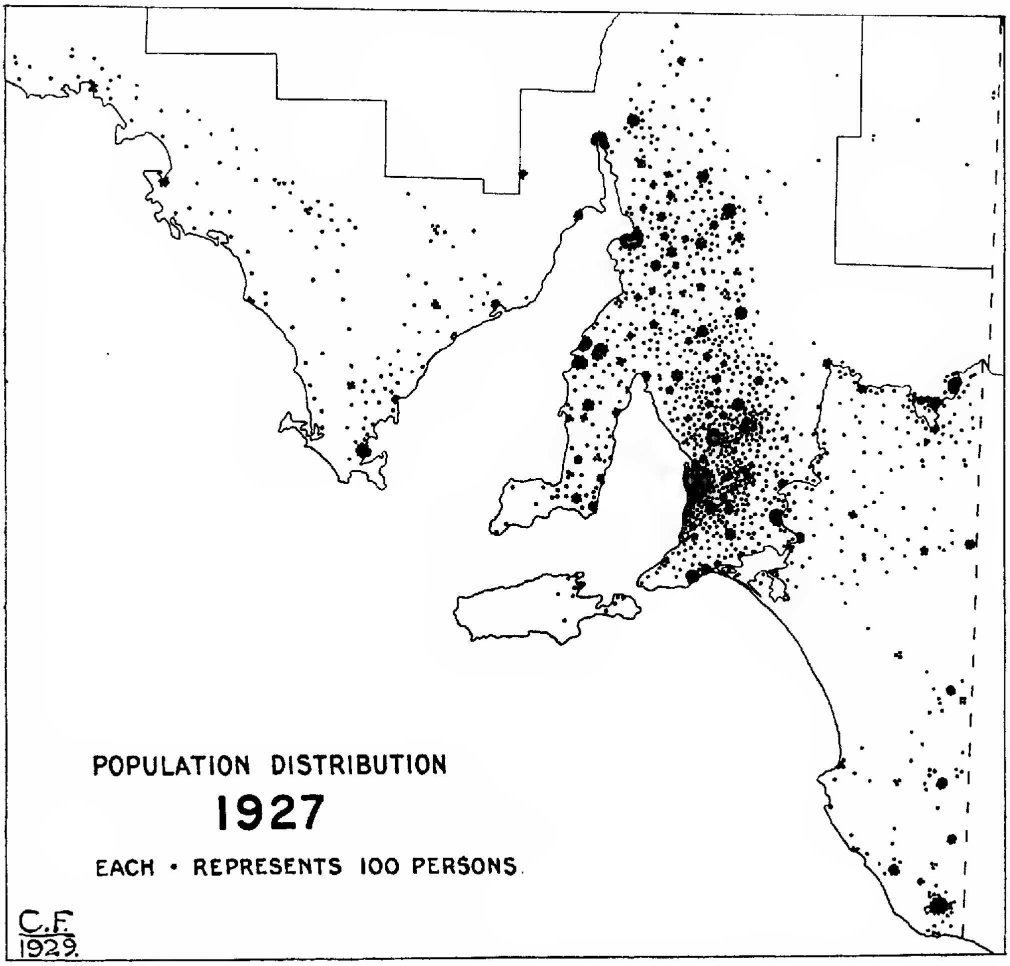


Fig. 7b.

Spot map of the population of South Australia in 1927, for comparison with that of 1861 (fig. 7a). The county boundaries are shown. Each dot represents 100 persons. The factors controlling this concentration and dispersion are discussed in detail in the context.

Between 1861 (fig. 7a), with a population of 130,000, and 1927 (fig. 7b), with a population of 575,000, there is a period of 66 years. The alterations that have taken place are most marked, both in dispersion to the country districts and in concentration towards the metropolitan centre.

Copper has declined almost to vanishing point, and the three chief copper centres, while declining in population and importance, have adapted themselves as commercial, distributing, and residential centres for the agricultural areas that surround them. The coming of the stump-jump plough and the stripper, with later mechanical advantages, and the more complete adoption and perfection of scientific farming methods, have revolutionised wheat production. The discovery

of the value of "super." on these phosphate-hungry soils has been a most powerful factor in the successful extension of the agricultural areas.

The development of a great railway system, the provision of a remarkable scheme of water supply, the exploitation of the irrigable Murray Flats, the drainage of the South-Eastern plains and swamps, the opening of the Port Pirie smelting works and the Iron Knob iron mines, the establishment of the salt and gypsum industries—all these have influenced the methods and direction of growth of the population, and each will be dealt with in turn in succeeding sections.

The most striking population extensions of 1927, as compared with 1861, are the opening up of the northern districts, Yorke Peninsula, the Murray Mallee, and Eyre Peninsula, all of which are wheat developments, with the later extensive settlement within the valley of the Lower Murray, where irrigation is practised. Properly speaking, this valley is comprised in the narrow strip that margins the river, and lies between the Mallee uplands that border the valley on both sides. Above Overland Corner this valley may be from six to ten miles wide, below that point it is only one or two miles in width. Where the adjacent uplands and slopes are irrigable they are counted as in the Murray Valley.

The capital centre, for various good reasons, has grown prodigiously, and contains more than 55 per cent. of the total State population. The chief "islet" on the West Coast (Eyre's Peninsula) is Port Lincoln, a distributing centre, and in the South-East the town of Mount Gambier functions similarly. The largest country centre is the port and smelting town of Port Pirie, where the geographical controls of port and nearness to Broken Hill have led to the development of an important centre on a samphire swamp area that would, without these factors, have remained a small and unimportant wheat port.

Similarly, Iron Knob and its port (Whyalla) have developed under most difficult climatic conditions, on account of the extensive and rich iron ores there, and the ingenuity of man has contrived to bring many of the amenities of life to these otherwise unfavoured localities. Some centres, such as Kingscote (K.I.), Robe, and Victor Harbour—each of them in its turn having had high hopes as harbours, and even aspiring to the status of capitals—have had to yield to the judgment of mariners and to the growth of ships, and are now charming and valuable tourist and holiday resorts.

The trio of peninsular towns (Wallaroo, Moonta, and Kadina) is still in the process of adjusting itself to the changed conditions that followed the closing of the copper mines, and such adjustments, so common throughout the mineral regions of the world, are gradual and difficult; much more so when such towns have been so long established as mineral producers (sixty years). Port Augusta is chiefly a railway town (Commonwealth lines to Kalgoorlie, W.A., and Alice Springs, C.A.), and the present geographical conditions do not greatly favour its development as a port.

The spot map shows, generally, how great is the influence of topographical features on the distribution of the people. The effect of the abrupt scarp faces of the Mount Lofty horst is most marked, and shows best in the detailed map of the Adelaide Plains. In a paper on "Some Population Gradients in the United States," by Dr. A. B. Wolfe, in the "Geographical Review," April, 1928, pp. 291-301, similar striking effects are clearly shown. In South Australia the controlling influence of mountain escarpments, of river cliffs in areas of irrigation (Murray Valley, not shown clearly in these figures owing to the small scale of the maps), of the contrast between plain and plateau, between the lower swamplands (*i.e.*, Port River estuary, head of Gulf St. Vincent, etc.), and the neighbouring dry lands,

Again, in a paper entitled "A Picture of the Distribution of Population in Pennsylvania," by C. E. Batschelet, in the "Geographical Review," July, 1927,

pp. 429-433, we see the remarkable effects on population distribution of the ridges and valleys of that State. The type of population distribution shown by the inter-ridge alluvial plains of the Gladstone-Kapunda region, and even in the garden and orchard areas of the Mount Lofty Ranges, compares with that of the valleys of Central Pennsylvania; the South Australian example would show up in a well-marked manner on a large scale map, but with a much less dense population and with a less striking distribution. The effects of the curving ridges of the tilted blocks of the Mount Lofty horsts on the distribution of farms and townships is also shown in the arrangements of transport systems and schemes of water supply.

Fig. 18 shows the extraordinary way in which the broken coastline of the State has led to the development of ports. But only a few of these have any noteable trade. The population "islets" along the coast, as shown in fig. 7b, should be studied in comparison with the details of harbour tonnage shown in fig. 18. Some of the inland centres are almost wholly "railway towns," formed at important intersections, notably Tailem Bend and Peterborough. The town of Murray Bridge is a river and railway port, and apart from local fertile river flats, owes its existence to its selection as a site for the first bridge across the Murray in South Australia (see Proc. Roy. Soc. S.A., vol. li., 1927, p. 225).

Most other "islets" of population shown in the spot map for 1927 are agricultural centres, such as Clare (wine and fruit district), Balaklava (wheat), Burra (wheat and wool), Gawler (hay and dairy produce), Maitland (wheat), and Renmark and Berri (citrus and dried fruits), and so on. Each centre attracts and holds its population according to the inexorable laws of nature, and even in the smallest villages one may trace the influences of the factors of climate, soil, topography, and other local geographical conditions.

In concluding this section on the general distribution of population in South Australia as we see it at the present day, with its lateral extensions and northward progress towards areas of less favourable conditions, one may quote the interesting conclusions of Dr. Guy-Harold Smith, an American geographer, who has published a paper on "The Populating of Wisconsin" ("Geographical Review," July, 1928, pp. 402-421).

Dr. Smith says that in northern Wisconsin, "because of the lack of easily cultivated prairies, the low intrinsic value of the land, and the severer climatic conditions (greater cold, etc., in this case), the agricultural frontier passed very lightly across that part of the State, leaving in its wake only a sparse population." He speaks of the evils of certain types of land dealers in such areas, and of the difficulties of the struggling "marginal farmers." We must remember, however, that it is among these marginal farmers that are at times developed those methods of farming that have greatly increased our production, to say nothing of the thrift, courage, and tenacity of purpose developed under such conditions.

There is a proverb to the effect that character is not strengthened among those on whom the snow does not fall, *i.e.,* those who have no adverse climatic conditions to contend with. In South Australia there is no snow to fight against, but there are climatic enemies equally difficult to overcome. It is to the cumulative effect of generations of such effort that the character of the people of this State owes many of its best qualities. In such manner do geographical factors influence not only the material but also the moral welfare of man.

(d) *Dispersion and Centralization.*—In following the movements of the population of the State we see two forces at work, or rather two sets of complex forces:—

(a) One set attracting or driving the individual out to the open spaces, to contact with the soil, to the margins of settlement, to the hard work of agricultural and pastoral pursuits, with the prospects of an ultimate rich reward.

(b) Another set of forces attracting individuals to the metropolitan area —for work, for educational facilities, and for the general amenities of urban life—with fair prospects of more immediate comfort and less anticipation of high subsequent reward.

The second force has become more marked in later years, with the coming of the comforts of modern reticulation, lighting, transport, amusements, department stores, etc., that add to the attractions of life in larger centres. The development of manufactures in the metropolitan area and the better educational facilities that are naturally available add to this attractiveness. There is a decreasing demand for farm labour per farm owing to the increasing use of agricultural machinery. Fewer workers are needed in the country; more are needed in the city. The "inexorable laws" of supply and demand are ever in operation. If too great a number of men left the country, so that insufficient farm products were available, the price of such commodities would rise, and the farm workers' wages would also rise relatively to those of the metropolitan worker; while an excess of workers in the city areas would in a similar manner lead to a reduction of urban employment or wages. A movement would then gradually set in from the city outwards.

Urbanization or centralization, or, as it is sometimes called, the "unnatural" growth of cities, is to be found in all latitudes and among all peoples. It is more notable in industrial areas, and this State is somewhat outstanding in this respect as an almost purely agricultural and pastoral country. An important factor operating here to make one urban centre, instead of two or three, as has been shown elsewhere by the writer, is the general charm and comfort of life in Adelaide, and the complete lack of any other centre with geographical advantages that are at all comparable with those of the capital city.

For the first few years of the State's history the districts around Adelaide really constituted the whole State, though a limited number of sheep farmers penetrated into the more remote parts in a remarkably rapid manner. Thus there was at first no notable concentration nor dispersion. In about ten years, partly under the spell of mineral (copper) discoveries, and partly because of the knowledge of the outback country that was gained by the sheep farmers, dispersion set in. This has continued throughout the life of the State, now flowing northward, or eastward, or westward, with a steady continuous growth in the South-East, and more recently in the Murray Valley, and with occasional considerable retreats where a succession of dry seasons drove settlers back from areas of less reliable rainfall that had been temporarily occupied. Generally speaking, periods of dry seasons accentuated concentration in the metropolitan area; good seasons favoured and assisted dispersion.

In the graph (fig. 8) we see the manner in which the relative proportions of country and city population have waxed and waned. Many factors influenced this matter, some of which have been detailed above. The opening up of fresh railways (and, to a less extent, ports) has had an enormous influence, as also has the development of a widespread system of water supply. In 1861 the outside counties still had fewer people than County Adelaide. Ten years later the position was reversed, and we find considerably more people in the country proper.

This condition of more rapid country extension continued for twenty years, and the maximum proportion of country population was reached in 1881. But while the population of the metropolitan county continued to grow rapidly through the 'eighties, there were periods of depression—of dry seasons, poor yields, and generally low prices—and the outside counties increased but slowly. They continued to lose their adult population (many going far afield to New South Wales, Western Australia, etc.), and such increase as is shown was due to the excess of births over deaths and departures.

Before 1900 the County of Adelaide had a population equal to that of all the other counties. About 1910 the growth curve of Adelaide (city and county) took a remarkably accelerated upward turn. This has been ascribed, popularly, to the electrification and extension of the suburban transport; but this factor must be considered, in large part, an effect rather than a cause. The underlying cause was a general prosperity, due to good seasons, more work available in the city, good yields and prices, high copper values, and other cumulative general effects due to improved farming methods. The development of manufactures, and the increase of city amenities, also contributed to the result. About this time the curve of country population also took an upward turn, less marked than that of the city.

Between 1910 and 1920 the curve of population is distorted and abnormal, as is practically every other curve indicative of the activities of the State, owing to the disturbing influences of the war; this was added to, locally, by the 1914

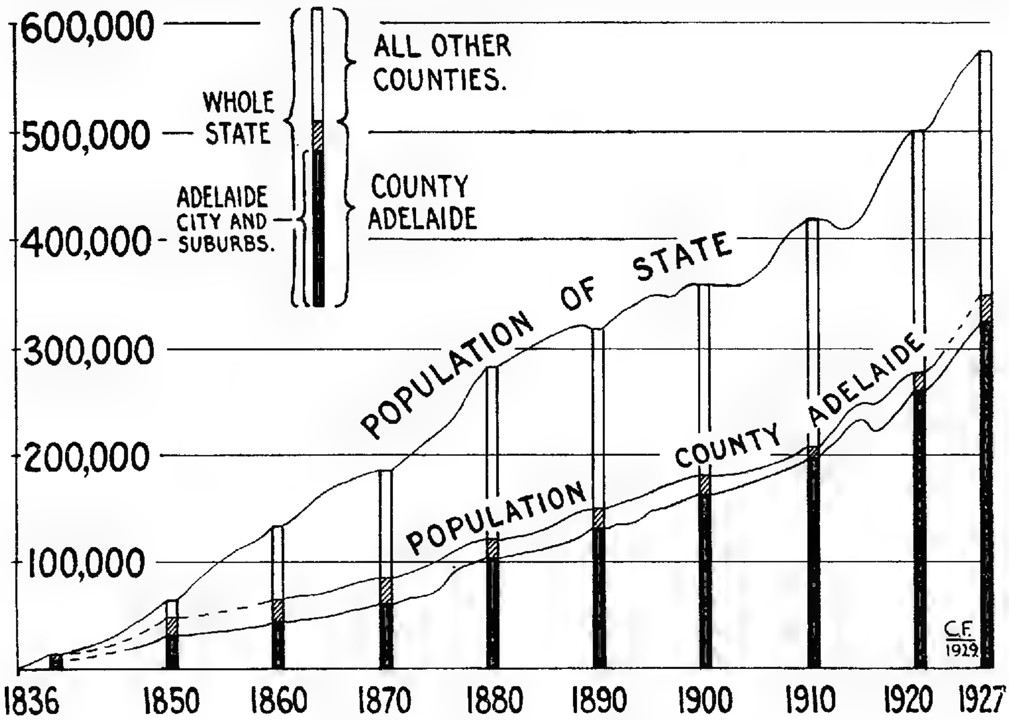


Fig. 8.

Graph showing the metropolitan and country distribution of the population of the State. The whole column shown at each ten-year interval represents all the people of the State; the black portion represents the metropolitan dwellers, and the shaded portion the remainder of those living in the County of Adelaide. Thus the upper unshaded portion of the column represents those living in what might be called the "Country Counties."

drought. Strangely enough, the city population shows these movements more than the country, possibly a reflection of the fact that there is less natural stability in the population of the metropolitan area.

By 1920 peace had come, demobilization had been effected, and repatriation was at work. Tremendous efforts were made to increase the number of people on the land—in the wheat areas, in the South-East, and more particularly along the Murray River. But it was still to be learnt that movements such as this cannot, even with almost unlimited financial resources, be artificially forced beyond

a certain limit. Difficult problems arose of farming practice, of irrigation methods, of individual finance, and of markets.

Still, though there was much failure there was much success, and, with further good seasons and high prices, a remarkable period of prosperity followed. The population graph of the city (and of the County of Adelaide, which is almost parallel) went ahead at an unprecedented rate. At the same time, the rate of population increase in the outer counties flattened out (decreased), and is at present at a general lower rate than has previously been experienced, even lower than in the "depression years" of 1885-1900 (see fig. 8).

There is a third general population movement that should be noted. In the preceding paragraph the metropolitan area, which is that portion of the County of Adelaide within about ten miles of the General Post Office, comprising the city proper and the suburbs, has been loosely referred to as "the city." The city proper is really the central municipal area within the belt of "park lands," and under the control of the Adelaide City Council. While the whole metropolitan area has rapidly increased its population, there is, and has been for ten years or more, a distinct outward movement from the city proper into the suburban areas. On the one hand, there has been the "pull" of new and well-planned suburbs, more pleasant surroundings, "breathing space" and garden facilities, with comfortable transport, electric light, sewerage, and a good water supply. On the other hand, there has been in the city (where in 1842 practically all the metropolitan area was contained, *vide* Kingston's map of that date) a strong demand for space for factories, storehouses, motor garages, shops and offices; rows of small and old houses, dating back to the very early days, have been displaced, and the occupants have moved outward to the suburbs—a wholly desirable movement.

The writer has been continually surprised to find, in the course of his enquiries into the geography of South Australia, that various movements and tendencies that have been thought worthy of comment, and yet regarded as quite local and accidental, prove on further enquiry to be matters of world-wide interest and development. Take, for instance, the outward movement of population from the centre of the city of Adelaide, which we have watched going on quietly and naturally from day to day, and which has been dealt with in the preceding paragraphs. Compare this with a statement by Brunhes ("Human Geography," p. 389):—"The great city may even become empty at its centre, a fact which may be verified at Paris, London, Berlin, Vienna, or New York. This is not a question of an ephemeral and exceptional fact, but a fact of urban geography that is becoming more and more general. A German author (Hermann Schmid, Munich, 1909) has given to this phenomenon the name of 'Citybildung'; he shows that this progressive diminution of the centres of great cities dates only from the middle of the last century."

Thus, if we wish to visualize a "moving picture" of the population movements, as we may do from a consideration of the facts and graphs here supplied, we should picture a continuous general growth of the State, partly by immigration but more largely by excess of births over deaths. With this there is a general outward dispersion, an ebb and flow movement, gradually further and further outwards over the whole area of "The Counties." Accompanying this, a continued and marked inward concentration, partly by immigration additions, partly by the continuous stream of young people coming in from the country, increasing the urban population in an astonishing way. But in the very heart of all this concentration, in the city proper, there is a gradual outward movement to the suburbs; thus the broad zone of the suburban areas is continually growing by additions both from without and from within.

The general movements of people noted in this section may be abundantly paralleled in many young agricultural lands, and we may again quote Dr. Guy-

Harold Smith, of the State of Wisconsin, U.S.A. *(loc. cit.)*, to the effect that in Wisconsin the northward movement of the human frontier, towards the area of less favourable conditions, is accompanied by an "intensification of the rear, commonly called the urbanization movement." Thus there are, he notes, two tendencies, one towards a dissemination of the rural inhabitants, and the other towards a centralization of the urban peoples. This latter movement is more marked in South Australia on account of those peculiar geographical factors of topography, coastline, area, climate, and soil that have led to the concentration of this urbanisation in *one* city, instead of in several, as is more usually the case. It is inevitable that the eastern plains of the Spencer-Vincent Sunkland (that is, the Lower Adelaide Plains), because of their geographical advantages, will continue to be the dominant urban centre of South Australia.

(e) *Production: Agricultural.*—The geographical factors of topography, soil, temperature, and rainfall—coupled with the lack of coal, water power, timber,

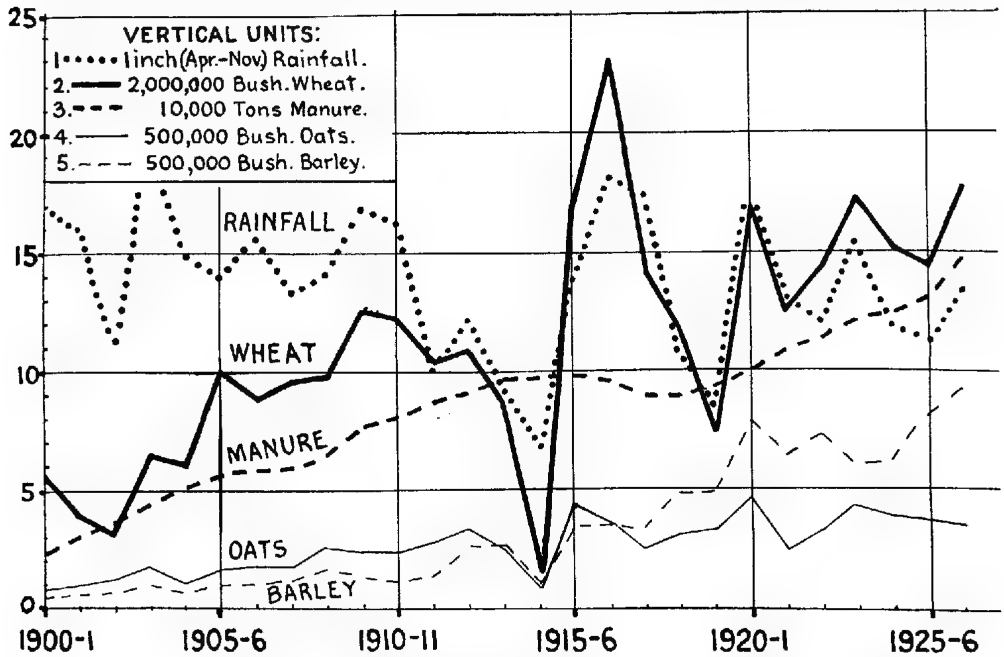


Fig. 9.

Graph of the total production of three representative crops during the years 1900-1927. With these are graphed the rainfall of the crop-growing months (April-November), and also the increasing amount of artificial fertilizers applied. Note the increase of crop production; also the controlling influence of rainfall and fertilizers. (After W. L. Johnston, Government Statist.)

etc.—determine the rôle of South Australia as an agricultural and pastoral State, and not as a manufacturing one. Ninety years of practical experience and scientific study have disclosed a wide variety of products suited to the prevailing conditions of the various localities, as referred to in previous sections. We may here discuss, briefly, the chief agricultural products, and the bearing of that factor on the growth and movement of population as detailed in the final chapters.

It is not proposed to invade the domain of the agriculturists who have so capably demonstrated to us the chief factors influencing our agricultural production, and whose research and teaching and direction have led, and are leading, us on to still greater production and better grade products. We are here interested only in these matters as factors influencing past and future population movements.

The "Mediterranean" character of the climate of South Australia was very early recognised; the vine, the olive, the fig, and the sheep were introduced almost in the beginning, and it must have been quite early in our history when the first crop of wheat was successfully grown on the Adelaide Plains. Ninety years have demonstrated the particular suitability of our soils and climate (north of the latitude of Adelaide) for wheat production, and mechanical and scientific skill, coupled with courage and persistence, have solved many of the special problems which the conditions of this land imposed.

The general facts regarding the geographic controls which led to the adoption in this State of wheat-growing as its dominant industry have been excellently set forth by Professor A. J. Perkins, the State Director of Agriculture (A.A.A.S., Handbook, Adelaide, 1924):—"Scanty population, pioneering conditions, and vast distances from the markets of the world were the chief economic factors that helped to shape our agricultural practice. These stipulated the production of exportable commodities that would keep readily and indefinitely, that could be conveyed at low cost over long distances, that could be produced with a minimum of labour, and that offered no special marketing difficulties. On our slow emergence from the pastoral era, we realized that, subject to the adoption of labour-saving devices, wheat would satisfy these conditions, and, fortunately, experience soon proved that it could adapt itself admirably to our climatic conditions and to most of our soils."

The greatest stimulus to increased production was possibly that of the application of superphosphates to soils that are peculiarly lacking in that plant requirement. This fact is noted in the graphs here presented (see figs. 9 and 22). Another important fact was the introduction into the mallee scrub—the dwarf eucalypt plant suite which originally covered practically the whole of the plains that are now the wheat areas—of the special technique of "a roll, and a burn, and a stump-jump plough" for rapidly turning scrub lands into wheat fields.

Throughout, under the capable direction of the Department of Agriculture, supported by the co-operation of a widespread net of intelligent and enthusiastic farmers (Agricultural Bureaux), methods of tillage have been continually improved, more appropriate wheat varieties introduced, and, latterly, more attention given to the proper treatment of stock and pastures. With this, also, is to be noted the development of more intensive research and applied discovery that is represented by the Waite Agricultural Institute. Apart from the essential factors of (a) Water Supply, (b) Transport, and (c) Markets, this influence of scientific direction, research, and co-operation has been, and must continue to be, one of the chief human factors contributing to the progress of the State.

The spot map of the State prepared in fig. 10 shows, in a graphic way, where the most favourable wheat areas lie. The north central areas have the advantage of older settlement and nearness to markets, but both the eastward and westward wings (Murray Mallee and "West Coast," respectively) continue to increase production. The south and central areas have also the most reliable rainfall—an important factor in the more intensive farming of the available land.

The geographical factors are the soils, topography (compare fig. 3a), rainfall (fig. 3b), and summer temperatures for ripening and harvesting. Potentially fertile soils and good harvesting climate extend beyond the county boundaries far to the north, but the rainfall is too low, and is less reliable at that. The southern boundary of the wheat-producing areas, clearly shown in fig. 10, is not so easily explained. The writer has appealed to the Director of Agriculture (Professor Perkins), for whose ready advice he is much indebted. Professor Perkins states that many factors are involved. The chief one is that in the southern areas, where the soils are good, the higher rainfalls and the nearness to markets

enable the agriculturists to produce crops that pay better than wheat. There is also the climatic factor of coldness and wetness, which prevents the wheat grown to the south from developing the special milling qualities required. The poorer soils of the "toes" of the three peninsulas (Eyre, Yorke, and Fleurieu) have already been mentioned; this influence is distinctly seen in fig. 10. There is also a hay belt running east-west through the Kapunda district, but this is due, in the opinion of Professor Perkins, more to nearness to (diminishing) markets and to the influence of farming tradition than to soil or climatic conditions.

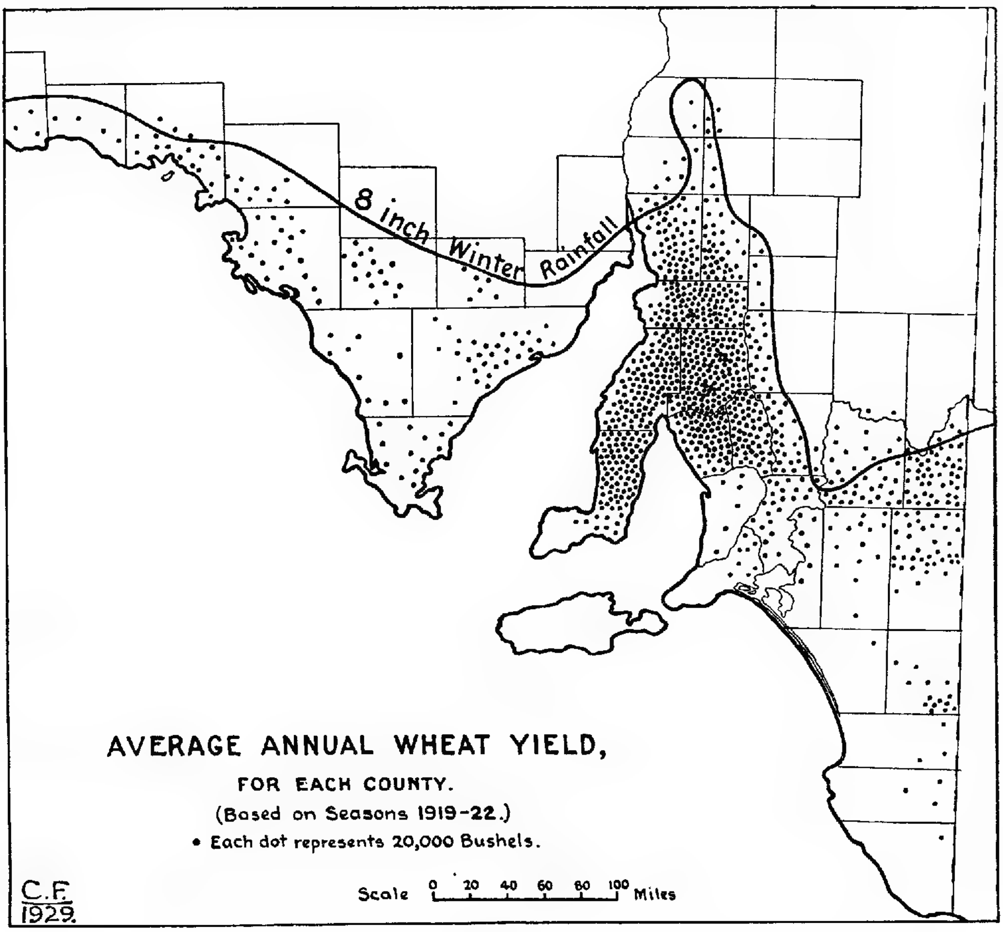


Fig. 10.

Spot map of the State, showing the wheat yield over four selected average years, 1919-1922. The outlines of the counties are shown, also the line of 8-inch winter rainfall. This line forms the northern boundary of the wheat area, the southern boundary of which is roughly along the latitude of Adelaide, 35° S.

The extension of the counties, as dealt with in a previous section (see figs. 4 and 5), the development of the water supply (figs. 13 and 14), the extension of the railways (figs. 15 and 16), roads and motor cars (fig. 17), and harbours (fig. 18)—each of these has had an important influence on the productiveness of the State, and thus, on the growth, distribution, and movements of population. Such movements are dealt with in later plans and sections, but it may here be noted that there has been a steady and satisfactory increase both in acreage and

yield of the chief crops, as also of the vines, citrus, and dried fruits. Given a continuance of satisfactory markets, abroad and local, and thrifty provision against the inevitable occasional recurrence of droughts, there is every reason to contemplate continued expansion of production, within the proclaimed areas of the counties, with consequent growth and prosperity for the State.

(f) *Production: Pastoral.*—The flocks and herds have already been referred to. Much that was written in the preceding section *re* improved methods, scientific direction, etc., applies here, and need not be repeated.

The progress of pastoral occupation and production in the State is clearly shown in fig. 11. The factors that affect the agricultural operations also affect the pastoral, but there are certain exceptions. The question of transport is less important, and the provision of water must be extended to include bores, wells, dams, rock-holes, etc. Stock extends much further northwards, in places right to the boundary of Central Australia, and thus comes into the areas of exceedinly low and very unreliable rainfall. The influence of drought years is much more marked in pastoral than in agricultural production. The effect of the drought of 1914, for instance, is shown by the fact that the number of sheep in 1913 was 5,073,000; in 1915 there were 3,674,000—a decrease of 1,399,000, where normally an increase of half a million would be expected (see fig. 11).

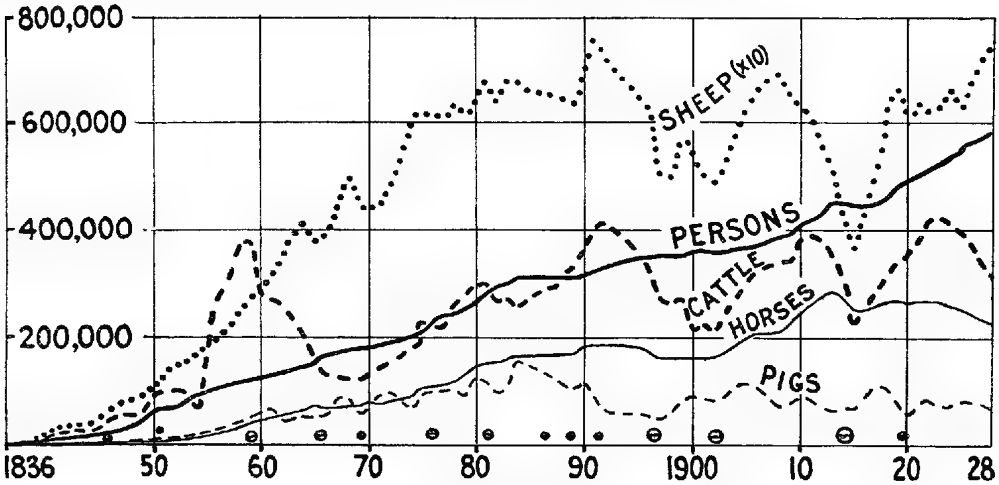


Fig. 11.

Graph showing the numbers of sheep, cattle, horses, pigs, and people in South Australia for each year from 1836 to 1927. The notable drought years are also marked on the graph, as barred circles. The sheep numbers are to be multiplied by 10. Note the absence of increase since 1890; also the disastrous influence of the later drought years.

South Australia is a pastoral country, labouring in the outer areas from two great difficulties: (a) water for stock, and (b) the danger of overstocking and thus eating out the native vegetation owing to the incidence of the drought seasons. The latter question is now being made the subject of special enquiry; the former has been carefully studied for many years by the man on the land and by the geologist and the engineer, and general provision by means of artesian and subartesian bores, dams, wells, and rock-holes is available up to certain limits.

Apart from the overstocking with cattle that took place in the late 'fifties, the increase of stock generally, up to the year 1890, kept parallel with the increase of people, and with the opening up of the land (see fig. 11). The progress of cultivation, of course, robs the stock of some area, but this is offset by the practice

of mixed farming, which enables more sheep to be carried on a farmed area than were carried there when it was a sheep-run alone.

The disturbing fact revealed by fig. 11 is that since 1890 (38 years), although the population has practically doubled, there has been no increase in the numbers of cattle and sheep. There are not so many sheep as there were in 1891, and cattle are many tens of thousands fewer. The fact appears to be that South Australia is not growing enough meat to feed her own people, if one may judge by the continued reports of imported stock for local consumption. From the broad geographical point of view, this position is not at all satisfactory, and while two of the contributing factors appear to be (a) a succession of dry seasons in the north, and (b) the utilization of sheep and cattle land for agricultural production, the position does not at present enable one to contemplate future pastoral

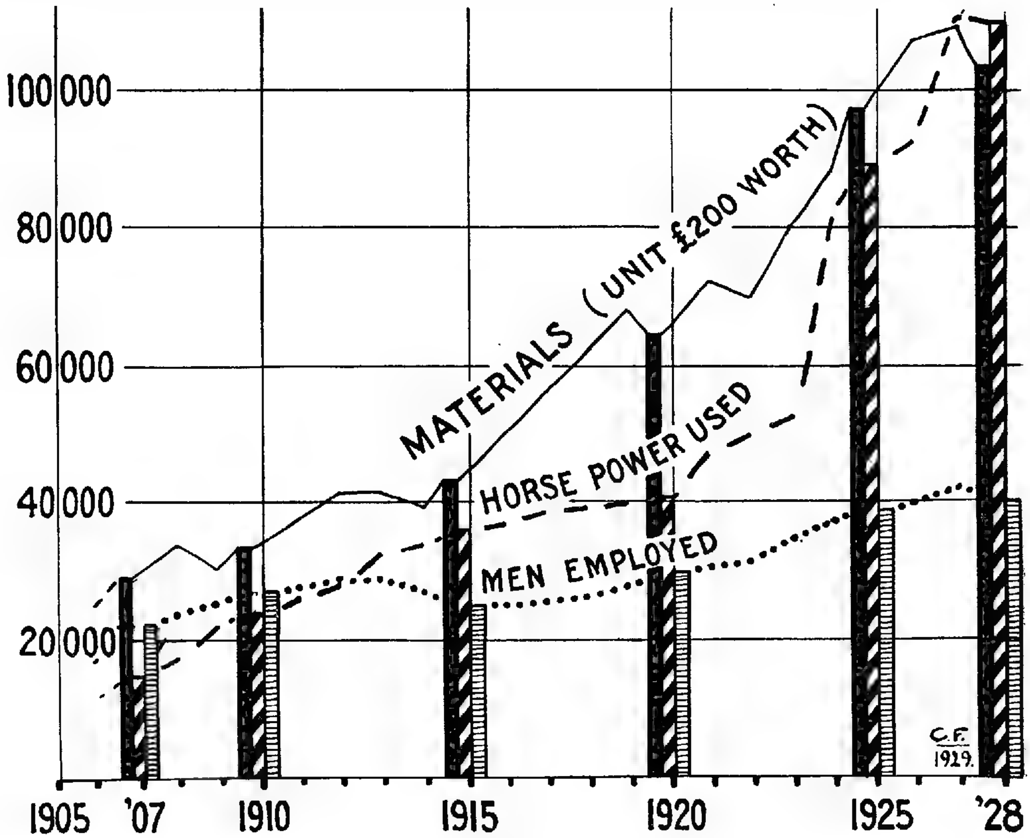


Fig. 12.

Graph showing the manufacturing progress in power, materials, and men from 1907 to 1928. In 1907 there was less than one horse-power used per man employed; in 1928 there was nearly three horse-power used for each man employed.

production with the same comfortable satisfaction as is possible in the case of the agricultural and horticultural products.

(g) *Production: Manufactures.*—The third and last type of production into which we are led by our enquiry is that of manufactures. The geographical advantages of this State do not lie in the direction of secondary industries, and the manner in which manufactures have progressed during recent years is a tribute to the available directive ability and to the workmen's skill and industry,

that have made such rapid progress and extension possible in spite of unfavourable conditions.

In fig. 12 we may see the advance made in this matter during the last 22 years. A general manufacturing country requires to be rich in Power (coal or water power), Materials (iron, other metals, and timber), and Men (skilful and contented craftsmen and operatives). South Australia, owing to its low relief and rainfall, has no water power, nor has it commercial supplies of coal; all power is produced from imported coal. She has iron, but it must be smelted elsewhere, to be re-imported as steel; there is at present no other production of metallic ores. She has directive ability and workmen alone, and with this it has been possible so far to fulfil the major portion of local requirements along certain lines, and even to export to outside markets (notably in motor bodies, furniture, etc.).

Fig. 12 shows the increase in the number of men employed, but the much more rapid increase is in power and materials (both of which must be imported). It is safe to look forward to a future for this State in supplying a good proportion of local requirements in manufactures; even more than at present. There are lines in pottery, textiles, etc., for which the material is at hand; but while outside markets may continue to be held and even further invaded, the geographical indications are obviously adverse to any extensive development in that direction.

The extent to which our manufactures depend on local markets is indicated by the manner in which (as shown by the detailed tables, specially supplied by the Government Statistician) the various factors rise and fall according to the incidence of local climatic conditions. By far the most stable factories are those that deal with local raw materials, or with local consumption, or both, as instanced by the following articles:—Soap, candles, leather, wattle bark, bricks, tiles, earthenware, lime, plaster, cement, salt, sugar (refining), fertilizers, bacon, ham, butter, cheese, confectionery, flour, jams, pickles, sauces, beer, wine, brandy, rugs, blankets, clothing, printing, boots, shoes, furniture, and agricultural implements. The future also must lie along these lines, with possible extensions in textiles and pottery for local sales.

There is a considerable proportion of industrial effort devoted to repair work. Some of the above-mentioned industries flourish in smaller country centres, such as Wallaroo (fertilizers), Southern Yorke Peninsula (salt), Mannum, Kapunda, and Ardrossan (farm machinery), with bark mills, butter and cheese factories, etc., in appropriate centres. The large town of Port Pirie is almost wholly an industrial centre, devoted to the lead-smelting industry. The tendency is for all the steel and wood manufactures to concentrate in the metropolitan area, and the graph shown in fig. 12 provides another of the explanations for the concentration of population in the metropolitan area. The tendency is for the larger factories to concentrate in the lowlands adjacent to the Port River, where sites are cheap, labour available, and land and sea transport convenient.

(h) *Water Conservation and Supply.*—Under the stimulus of the climatic conditions that prevail over the greater part of the State of South Australia, a scheme of water supply and conservation has grown up which is stated to be "the largest distributing scheme for country lands in the world, and unique in the history of water work schemes." The areas thus supplied are concentrated irregularly along the East-West belt of country that borders latitude 34. They do not extend to the north beyond the 10-inch line of rainfall for obvious reasons. With the following exceptions, the reticulated areas cover the whole of the country south of the lines of 10-inch rainfall, *i.e.*, "The Counties":—

(a) Northern Eyre Peninsula, in the more dry and less settled parts.
(b) The Polda water-bearing area (Eyre Peninsula), where good water is readily available underground.

(c) Southern and Central Yorke Peninsula (no local reservoir sites).

(d) Fleurieu Peninsula and Kangaroo Island, where the rainfall averages well over 20 inches.

(e) The so-called Murray Flats and their extension southward to the Murray Mouth (really the western segment of the plains of the Murray Mallee).

(f) The Southern Murray Mallee lands, at present supplied by a wide-spread series of bores in that extensive sub-artesian basin.

(g) The "Ninety-Mile" district, where artesian water occurs in places; there is a 20-inch rainfall and settlement is sparse, *vide* fig. 7b.

(h) The South-East, where the difficulties are mainly those due to an excess of water. There is a rainfall of 25 inches and upward, and no natural streams have been developed. Sub-artesian water is abundant and of good quality.

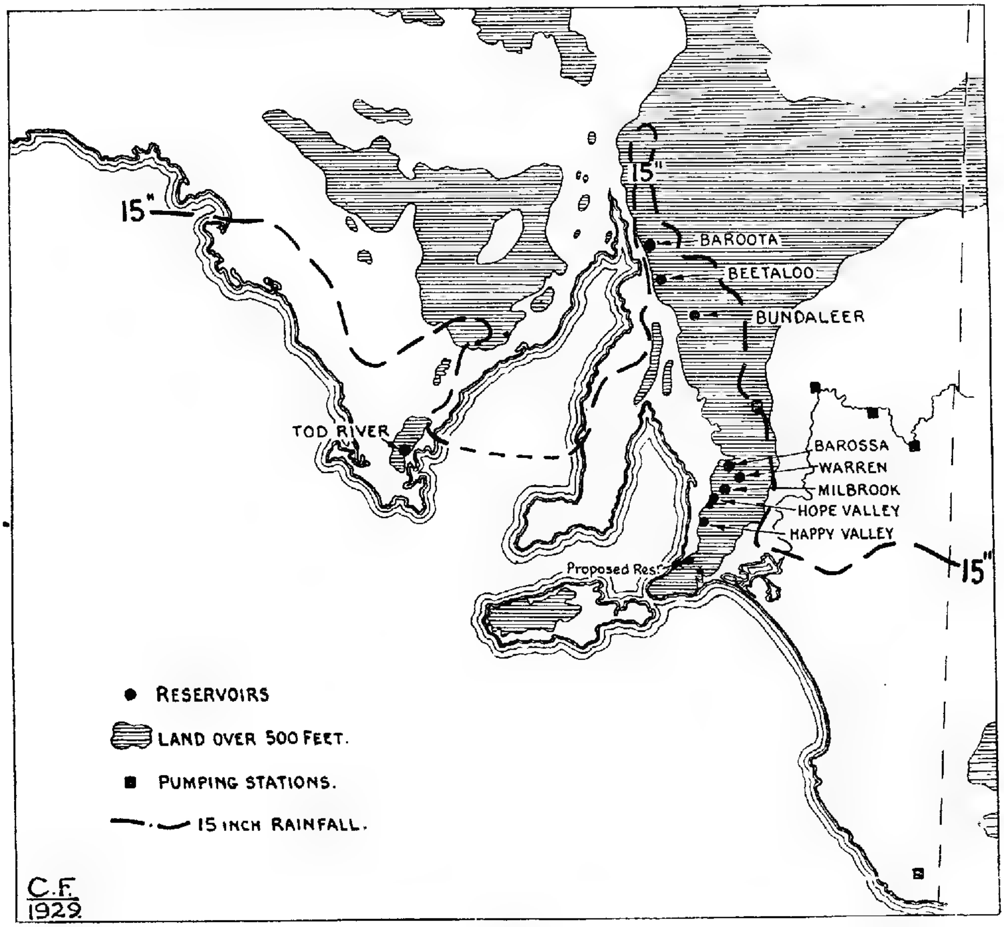


Fig. 13.

Map of South Australia showing the positions of the chief reservoirs and pumping stations, with the line of 15-inch annual rainfall and the land over 500 feet above sea-level (shaded). It will be noted that the reservoirs are bounded on the north by the 15-inch rainfall line, and otherwise by the 500-feet contour line. Thus the factors of topography and rainfall have controlled, and must continue to control, the possibilities of the extension of water supply schemes that are dependent upon local rainfall.

The history of the development of the great scheme of water supply above mentioned is contained in the various reports of the State Hydraulic Engineer. It will be touched on here only to show the way in which geographic controls have affected the scheme (figs. 13 and 14), and the bearing which this scheme has had, and will have, on the distribution and movement of population.

Reference to fig. 13, which has been drawn to show the two dominating geographic controls of water supply, demonstrates very clearly how the existence of this water supply is dependent on the Mount Lofty and Flinders Ranges, and the lesser uplands of Eyre Peninsula, with their height, their stream systems, and their better rainfall (it may be noted on any ordinary map that the greater part of South Australia has not developed any valley system); apart from the Lake Eyre Basin and the Lower Murray, it is only in the restricted area of the highlands that we find streams developed. In addition there are rivers which, formed in exoreic areas, must, of course, find their way to the sea across alluvial plains which give no further contribution to the streams (*e.g.*, Murray, Broughton, Light, Torrens). Even in the wetter South-East, partly owing to the youth of that uplifted limestone area, and partly owing to the porosity of the rocks, no natural drainage system has been developed; the difficulty in that area is not water supply but drainage, and large sums of money have been spent in drainage schemes with the object of rendering the land valuable for cultivation, grazing, etc.

There are four chief clusters of reservoirs for water supply, as shown by fig. 13;—

(a) The Mount Lofty Ranges, the water supply from which must ultimately impose a limit on the growth of the metropolitan area.

(b) The Southern Flinders Ranges, where there are at present three reservoirs, and others in contemplation.

(c) The highlands of the eastern part of Eyre Peninsula, where there are one large and two small reservoirs.

(d) The Murray River which, with its series of weirs, and fed by the rainfall derived from the mountain areas of eastern and south-eastern Australia, now ensures continuity of a supply of good water. Along its banks large areas of adjacent country are supplied by pumping stations from the river, apart from the irrigation settlements within the narrow valley itself.

(e) In addition to these water supplies, there are the bores of the vast area of the great North-Eastern artesian basin, as well as of the sub-artesian basin of the South-Eastern portion of the State.

(f) Elsewhere dams, shallow bores, wells, tanks, and rock-holes give an uncertain supply in areas of low rainfall and high evaporation.

It will be seen that this question of water supply, combined with and dependent on that of rainfall, is the dominating geographic control of population distribution in the State. All that has been done in the face of adverse conditions provides an excellent example of the way in which man ("Nature's insurgent son") has in the first place adapted himself to the geographic conditions, and in the second place, by the exercise of his ingenuity and skill, has turned on his environment and shaped it to his will.

Having considered the reticulation system in space, as set out in fig. 13, we come to consider its progress in time, as shown in fig. 14. We see that from the foundation of the State up to the year 1860 no systematic provision for water supply was made. The settlers of the metropolitan district mostly obtained their water from the River Torrens, or from the wells sunk in the irregular sub-artesian area that underlies Adelaide. Just prior to 1860 the growth of the State rendered

a reservoir necessary, and the rapidly growing metropolitan population (see fig. 8) has necessitated the provision of three subsequent reservoirs, each of increasingly greater capacity, with a fifth reservoir in contemplation in the position shown in fig. 13.

The progress of country reservoirs is shown also in this graph. The first large water storage was that of Beetaloo, established in 1890, following a period of dry seasons. Barossa and Bundaleer followed about 1902, which was a severe drought year. Subsequent to 1914, also notable for its low rainfall, the Warren, Baroota, and Tod reservoirs have been completed and put into operation.

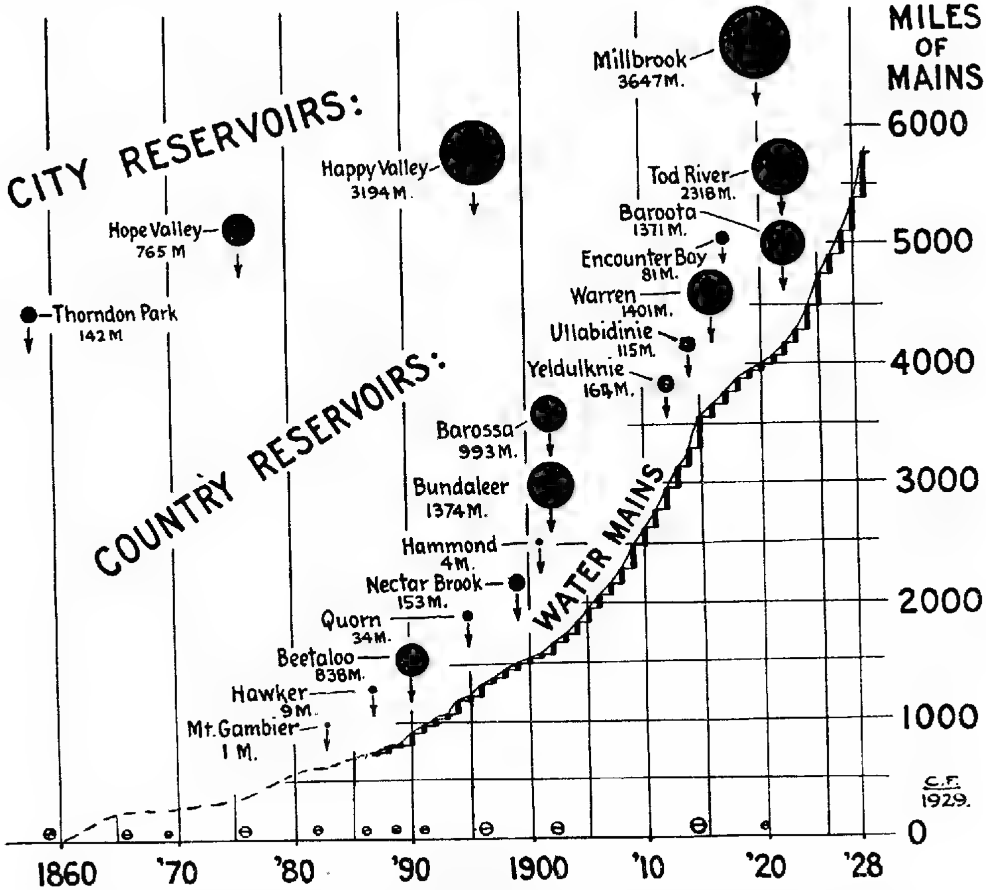


Fig. 14.

Graph showing the progressive development of water supply from 1860 to 1928. The dark vertical lines show the number of miles of water mains laid each year, the total reaching nearly 6,000 miles. The reservoirs supplying the metropolitan area are shown in one series, with the total capacity in millions of gallons. The arrows indicate the date of completion. The second series of black discs represents the country reservoirs with their capacity and date of completion; the barred circles at the bottom indicate the drought years.

One may see from fig. 13 the stimulating influence of dry seasons on the additional provision of water schemes. In a similar way the growth of the water mains has been alternately accelerated and retarded. The opening of big reservoirs, such as Barossa and Bundaleer, is naturally followed by a rapid increase in the proportion of trunk mains. This is also to be seen in the very great accelera-

tion shown from 1925 to 1928, inclusive, which have been the most progressive years of extension of water supply since the foundation of the State.

By comparison with the graphs showing population distribution and movement (figs. 7a and b), with the graph of railway construction (fig. 16), and with the graph showing the opening of the counties (fig. 5), one may see how all these factors are related in a causal way, each influencing the other and being influenced in turn. The water supply graph (fig. 14) clearly shows how the public conscience has been stimulated in the direction of adequate water conservation, particularly since 1895, when the Happy Valley reservoir was opened. The greater part of our water conservation work has been done since that date. Progress during the past forty years has been accelerated to such an extent that more than four times as much reticulation has been carried out in that period as was accomplished in the previous sixty years, and this takes no account of the unestimated supplies provided in the Murray Valley, and in the North-Eastern and South-Eastern artesian basins. The acceleration of development in the State, as shown in the population graphs and in the prosperity graph (fig. 22), is closely related to, and dependent upon, the progress of water conservation shown in fig. 14.

(i). *Transport: Railways.*—The relief of South Australia (fig. 3a) is such that apart from the barrier of the Mount Lofty and Flinders Ranges, and the lesser difficulties of the Murray River, the question of transport and communication is a relatively simple one. Roads and railways may be built in straight lines almost wherever they are required; but since the great concentration of population has necessarily been within the region of the Mount Lofty and Southern Flinders Ranges, the routes of the railways in those areas have been largely dominated by the existence of passes or gateways across the range, and by the long and narrow inter-range alluvial plains of the areas northward from Gawler to Hawker. This particular network of railways (Gawler-Hawker), see fig. 15, presents a fine example of topographic control of railway routes.

In an address, published in the "Public Service Review, S.A.," May, 1929, Mr. R. A. Gibbins, of the State Highways Department, brought forward some interesting facts relative to the manner in which "geographical controls" have acted, through the medium of the aboriginal inhabitants of this country, in determining the sites of modern communication routes. He said: "The aborigines showed a considerable amount of cleverness in selecting the best country to travel over in central Australia, and in that locality many of the roads and cattle tracks used today were at one time native pads. The Great Northern Railway, in many places, follows parallel with an old red ochre track used by the aborigines for unknown years. When Europeans made their way into the interior, they soon realized the advantage of utilizing the aborigines' knowledge of bushcraft. River crossings, bogs, quicksands, and flooded plains were found to offer no great difficulty to the white man when he called in the aid of the aborigines, who had made pads through these swamps and morasses for ages before the Europeans came. From each waterhole to the next the blackfellows had their pad, and this was invariably found to be the easiest way."

The date of the foundation of South Australia, so far as transport is concerned, corresponds roughly with the introduction of railways as a means of transport. The chief method of transport preceding those days was by canals, which had reached the zenith of their popularity and value and were waning. This transition period is shown in the fact that the present road from Adelaide to Port Adelaide lies along a wide belt specially provided by Colonel Light, the founder of Adelaide, for a canal to link up the Port River with the Torrens River —the proposed scheme being that the small sea-going craft of those days might actually anchor in the Torrens within the city of Adelaide.

There was considerable opposition to the introduction of railroads. The first rails laid down were for a tramway from Goolwa to Port Elliot in 1854, later extended on to Victor Harbour. In 1857, still in the face of opposition, the Adelaide to Port Adelaide railway was completed. There followed a period of twenty years, terminating in 1874, during which railway progress was very slow and intermittent. The chief driving power for the first northern lines was the stimulus of the mineral discoveries of Kapunda and Burra, and, as may be seen from fig. 15, these were the first long lines completed. The second period, from

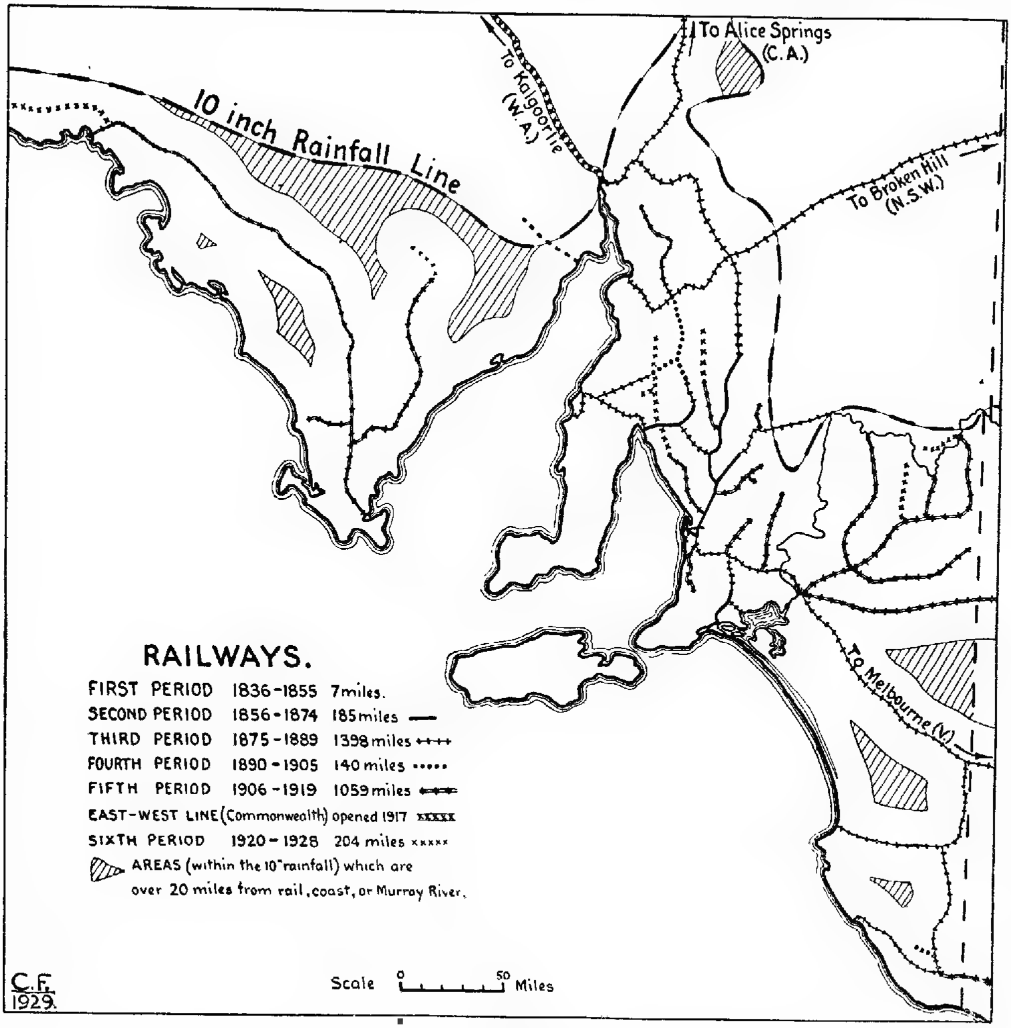


Fig. 15.

Map of South Australia showing the railways and their order of development in various periods. The shaded areas are those more than 20 miles from rail or coast. (See also fig. 16.)

1875 to 1889, saw 1,400 miles of railway built. This was the period that marked the beginning of the centralization of South Australia towards the city of Adelaide.

It has been remarked by geographers working in other countries, that railways are not usually built in long trunk lines but rather in short disconnected lengths. This is particularly true in South Australia, where it may also be noted

that the first efforts of the railways were in the direction of the development of outer ports, and in the direction of decentralization, as may be noted from the following early lines, the first-named terminus being a port in each case:—

(a) Port Pirie to Crystal Brook.
(b) Kingston to Naracoorte.
(c) Wallaroo to Moonta.
(d) Port Wakefield to Kadina.
(e) Port Augusta to Quorn.
(f) Beachport to Mount Gambier.

It was in 1880 that the first indications of centralization of the railways appear, with the construction of a line from Hamley Bridge to Balaklava, linking up the Wakefield-Moonta lines with Adelaide.

From 1890 to 1905, a period of fifteen years, very little progress was made, only 140 miles of railway being built. In the fifth period, from 1906 to 1919, there

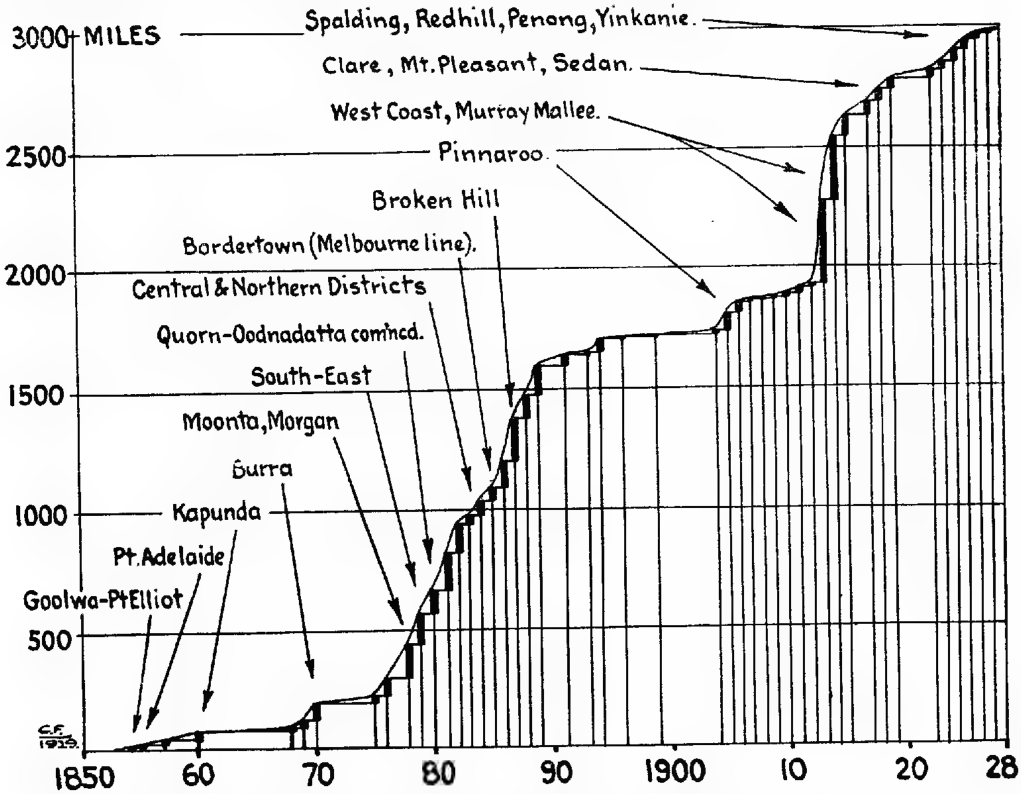


Fig. 16

Graph showing the number of miles of railway construction in South Australia for each year from 1850 to 1928. The lettering at the side indicates the most important lines included in each period of extension shown. There have been three periods of slow growth, with two intermediate periods of rapid extension.

was a very rapid development, corresponding to the rapid development of water conservation and of new wheat lands, as elsewhere described. In this period the West Coast lands were largely supplied with railways and the Murray Mallee with numerous lines, as indicated in fig. 15.

The East-West line (Commonwealth), from Port Augusta to Kalgoorlie, was also built during this period (opened in 1917). From 1920 onwards railway development has been slow, and limited to small spur lines, such as Clare-Spalding, Renmark-Barmera, Penong, Kimba, and Yinkanie, and the more important Long Plains-Red Hill section.

Professor Griffith Taylor, emphasizing the fact that it is not land but rainfall that must be catered for in this country, has stated that no railways should be run into areas of less than 10-inch rainfall. It will be seen from fig. 15 that practically the whole of the railway lines of the State are south of the 10-inch line of rainfall. Outside of this line there is a railway from Quorn to Oodnadatta, latterly taken over by the Commonwealth and recently extended to Alice Springs. This northern line was an effort on the part of South Australia to get in adequate touch with the Northern Territory, which was at that time controlled by this State. The line from Port Augusta to Kalgoorlie, a Federal matter, was built in fulfilment of a promise to bring Western Australia in closer touch with the Eastern States. Both these lines are thus more political than economic. The Port Pirie to Broken Hill line, on the contrary, arose from the natural geographic demand created by the rich silver-lead lodes of Broken Hill for a port at which it could receive its timber and coal, and send away its concentrates and other products.

The graph drawn in fig. 16, considered in conjunction with other figures, further illustrates the way in which geographic influences—topographic, coastal, climatic, and mineral—have affected the development of the railways. The extension of railways, in its turn, enormously influenced the State production. Professor Perkins is inclined to think that railway development was the most potent of all the human influences concerned in the opening up of the Murray Mallee and Eyre Peninsula (West Coast).

It may be noted from fig. 16 that in the opening railway period, which was one of slow growth, the first three long lines to be constructed were to copper centres —Kapunda, Burra, and Moonta, respectively. This construction, in turn, re-acted on the land through which the railways passed. One point of more than usual interest in this connection relates to the introduction of what is called "Mullenizing," about the year 1868. Mr. C. Mullen, of Wasleys, in the northern part of the Adelaide plains, cut down the mallee scrub on his property, finding a market for the wood among the railway gangs engaged on the construction of the Roseworthy-Burra railway. The idea occurred to him to lightly till the ungrubbed mallee country, where the timber had been cut down, with a roughly-made implement, and to sow wheat. He did so, and this means of rapidly placing the light mallee soils under cultivation greatly assisted in opening up further wheat lands.

With reference to the period of slow railway development between 1890 and 1912, it is not easy to see the reason therefor, except that the Murray Mallee and the West Coast not having yet been opened up, the country had reached a temporary limit of railway requirement. On the other hand, the reason may have been partly financial, owing to the long period of depression reaching back to 1885.

The rate of increase of railways at the present time has decreased, as shown by the flattening off of the curve for recent years in fig. 16. There has been a considerable amount of recent railway activity, but this has been mainly directed towards the strengthening of the existing lines (heavier rails, stronger bridges, etc.), and transforming much of the 3 ft. 6 in. gauge to 5 ft. 3 in. To get a full understanding of the way in which the railway construction has been influenced by climatic conditions, and of the very great influence which railway development has in its turn exerted on the general progress of the State, we should compare the railway map (fig. 15) and graph (fig. 16) with the production records (figs. 13 and 14), and with the population maps (figs. 7a and 7b).

At the present time the whole of the State within the 10-inch rainfall line has either a railway, or a coastal port or a river port within twenty miles, with the minor exception of the areas of relatively poor land shown shaded in fig. 15. The notable absence of railways from Fleurieu Peninsula is mainly due to the extremely rough country there, and the necessary high cost of construction. The absence of

railways on Kangaroo Island, although this island is the oldest settled portion of the State, is a reflection of the fact that, although the rainfall on the Island is abundant, soil problems are presented which have not yet been solved. The greater part of Kangaroo Island, except the eastern portion, is today almost wholly unproductive. The extreme west has been set aside as a "National Flora and Fauna Reserve." In the small regions that are productive there are ample and convenient ports to deal with the products.

The productive area of Yorke Peninsula, south of Moonta, is also without railways. This is a little more difficult to understand, but is probably due to the facts shown in fig. 18, which discloses the large number of useful ports that are found along the coasts of that region.

(j) *Transport: Roads and Motors.*—The early roads of this State were very simply constructed, much as they are in all the outback areas today. The method is to drive a vehicle across the level country along the most direct route presented, occasionally cutting down a tree so that the path may not be too sinuous. Constant use of such a path makes it a "road." For portion of the year such roads may be excellent, even for high-speed motor traffic. They tend, however, as early settlers found, and as the present-day pioneers know, to be dusty in summer and muddy in winter.

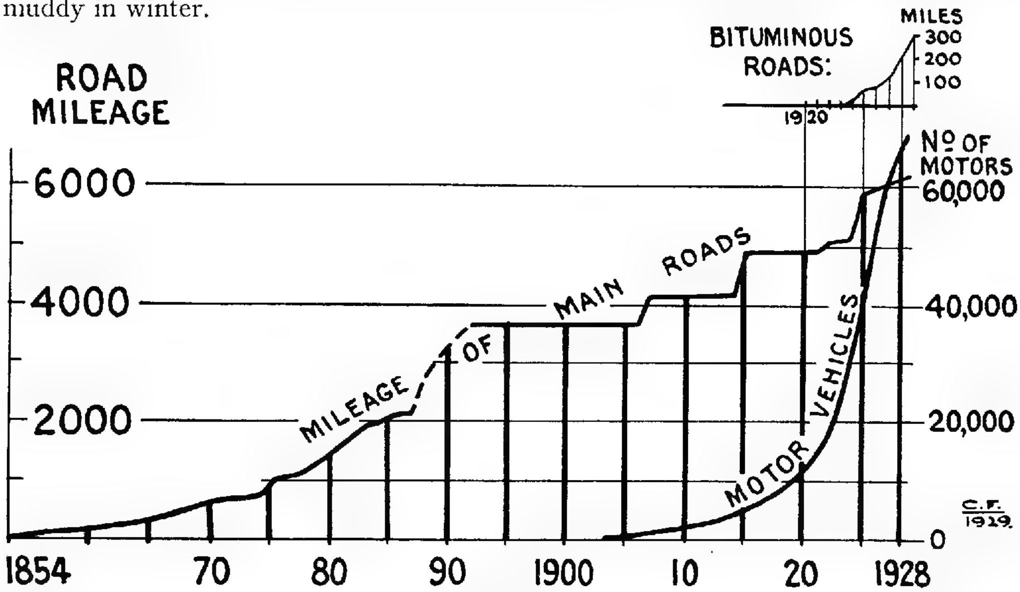


Fig. 17.

Graph of the progress of Main Road development from 1854 to 1929. The curve shows the progressive mileage of main routes, mostly according to proclamations made in successive Acts. The rapid increase in the number of motor vehicles from 1904 to 1929 is also shown, and a small added graph indicates the rapid construction of bituminous roads during the past six years.

Mr. R. A. Gibbins, previously quoted, tells us that in regard to road-making in this State:—"One of the early records refers to the 26th May, 1839, as having been a memorable day, in that on that occasion Governor Gawler officially commenced the making of the South Australian Company's important road between Port Adelaide and Adelaide. The record goes on to say that earlier in that month a settler and his horse had been speared by blacks while travelling on the site of the proposed new road. When the road was completed the Company erected a toll house in the vicinity of Hindmarsh, where the road-users paid their fees." Tolls were abolished about 1847.

The making of macadamised roads in South Australia has been greatly hampered by the fact that the available road metals are almost wholly silicious rocks (quartzites), which, from their character of breaking in flat rather than cubical pieces, and from their brittle and friable nature under heavy traffic, do not make lasting roads. Superior types of road metals have later come into use, but the coming of motor cars with the prosperous years succeeding 1920, and with the speed and comfort common to this vehicle, have demanded a type of road much superior to the ordinary macadam.

Subsequently, all the arterial roads leading from Adelaide—some commercial (the Port road), some pleasure (Glenelg and Victor Harbour roads), and others main communication roads (the Northern and North-Eastern, and the Prince's Highway to Melbourne), have been constructed either of bituminous concrete or of a somewhat lower grade road, called bituminous penetration. By June, 1929, there were about 300 miles of such roads constructed, about equal distances of bituminous concrete and bituminous penetration. The construction of these superior roads provides a most interesting and modern example of the inter-connection between the various geographic factors. The coming of motor cars, and motor traffic generally, demanded the construction of better roads, while the existence of these roads, in turn, encouraged and increased the use of motor transport. The rapidly accelerating development of both motor vehicles and superior roads may be seen from fig. 16.

It is noteworthy, in considering the way in which climate and other geographic factors have tended to isolate the fertile central portion of South Australia, that although this State occupies a central position, and her borders touch the five surrounding States of Western Australia, Central Australia, Queensland, New South Wales, and Victoria, no main road has yet been constructed leading from Adelaide to any one of these States.

In spite of this fact, there is considerable motor traffic to each of the States, particularly along the Coorong road to Victoria, and to a less extent to Broken Hill. While the Coorong road is the most advanced so far as construction is concerned, great stretches of it are merely tracks that have been made by the traffic without any construction whatever. In the outback areas, where drays and waggons (later, motor lorries) are the chief means of transport, the level plains permit of quite good tracks in almost any direction.

Among settlements separated by such vast spaces, it is natural that aeroplane development is important. In the Adelaide region excellent facilities for landing grounds and for flying conditions exist, and rapid extension is taking place. I am indebted to Mr. Churchill-Smith, Secretary of the State Aero Club, for the following information. In the year 1914 there was but one aeroplane in Adelaide, and that was a visitor. In 1929 there were 17 aeroplanes, owned and housed in the State, and regular services had been established officially with the Eastern and Western States, and privately with the South-East (Mount Gambier), Kangaroo Island, West Coast, and Yorke Peninsula. Of the 17 machines, 10 were the property of commercial bodies, four were owned by aero clubs, and three were privately owned.

(k) *Transport: Ports and Harbours.*—The settled portion of South Australia might really be considered insular in character, owing to the very high proportion of broken coastline which is available to-day owing to structural and geological happenings, detailed in Section 3 (figs. 2 and 3a). The influence of this coastline has been marked in many ways, apart from climate, etc.

The way in which early railway development tended to encourage the outer ports has already been described. The development of larger and smaller ports at various localities where the conditions were suitable has been most extensive, and it is likely that no Australian State, even including Tasmania, can compare with

South Australia in the provision of port facilities relative to the population and settled area.

In order to get an adequate conception of the port and harbour development of South Australia, an intensive study was made of the annual reports of the Harbours Board for the years 1922 to 1925. The results have been concentrated and set down in the map shown in fig. 18. It will be seen that almost every segment of the coast is well provided with harbours, though some of these are of quite minor importance. There is a break without harbours between Elliston and Port Lincoln. The west part of Kangaroo Island is too rough and open for ports, nor, unfortunately, is there any need for same. The eastern face of Gulf St. Vincent has no geographical advantages in the way of ports with the single

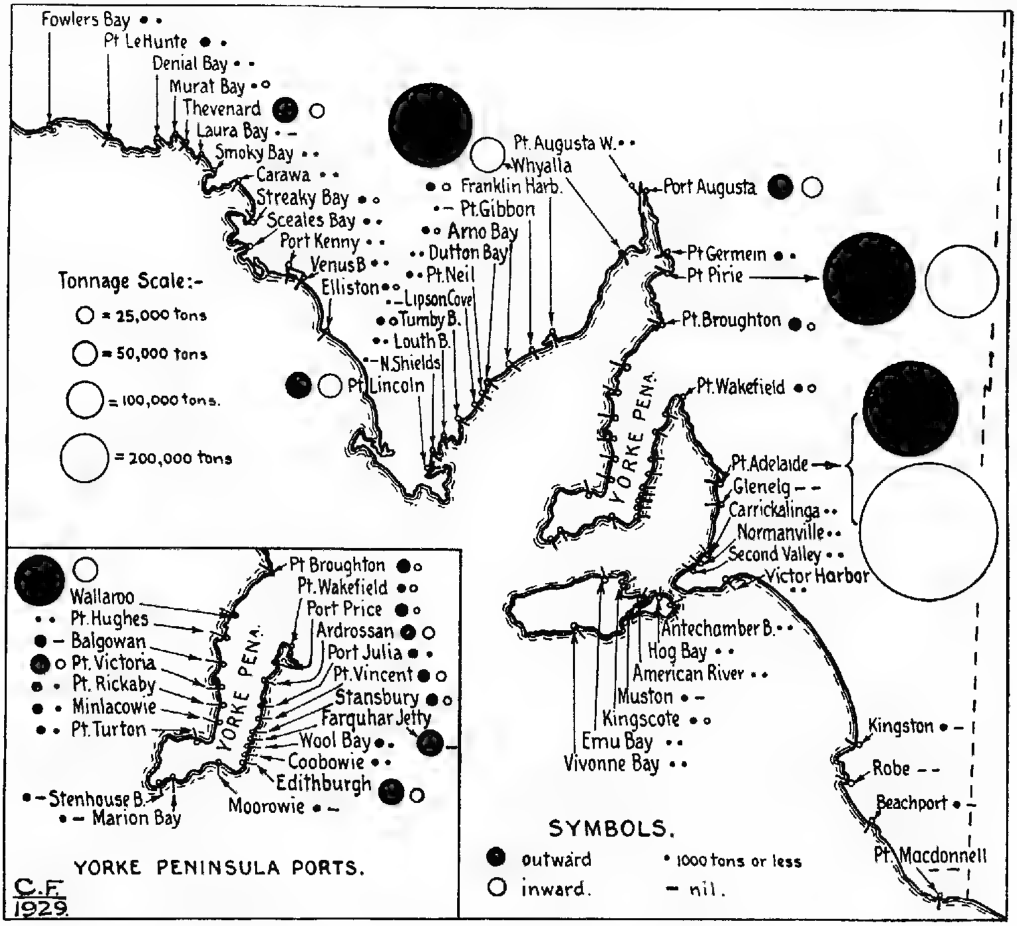


Fig. 18.

Map showing the positions of the harbours of South Australia, with a graphic representation of the inward and outward tonnage at each port. Note the correlation with coastline type, and with productions. Compare with settlement map (fig. 7b), wheat map (fig. 10), and railways (fig. 15).

exception of the Port River estuary, which has provided both inner and outer harbour for Adelaide.

A long stretch of coast, running from Fleurieu Peninsula to the South-East, has no harbour that is functioning at present, as will be seen from fig. 18. Indeed, it would appear from the map that the extension of port facilities has in many

cases been greater than was necessary, although possibly the present position is due to the later development of the railway system. This fact seems to be borne out by the relatively high value and use, as per fig. 18, of the Yorke Peninsula ports where there are no railway facilities.

Many of the ports are specialized owing to local geographical influences. Port Adelaide, with the greatest inward and outward tonnage, is the chief importing centre, and the chief exporting centre, of the State, hence its dominant position as shown in fig. 18. Port Pirie, second in importance, functions mainly in the export of concentrates from Broken Hill, and the import of coal and timber for that centre, but it is also an important wheat port. The exports of Wallaroo, Thevenard, and Port Lincoln are mainly wheat; that of Whyalla is iron ore; of Farquhar Jetty, limestone for cement making, etc.; and of southern Yorke Peninsula, salt and gypsum.

Throughout the whole of the smaller coastal ports of the State the dominant inward traffic is in superphosphates, and the outer traffic in wheat and wool.

There is a considerable coastal trade with small vessels, as may be seen by the number of ports with small import and export per annum. Although the two main gulfs break up the area of South Australia, from the point of view of railway development, to such an extent that the West Coast still remains unconnected by rail with Adelaide, the connecting influence of these gulfs for communication purposes needs no further description, nor any additional emphasis than is given in graphic form in fig. 18.

(1) *Education, Research, and Invention.*—Throughout the whole of the ninety years reviewed and discussed here, which have embraced the total period of the colonization and development of South Australia, the story is one of a steady, persistent, and increasing process of adaptation to environment. In the beginning, a population drawn from the advanced culture of England, from commercial rather than from agricultural centres, bred in an environment of abundant rains and cold winters, and used to the traditions and customs of an agricultural and pastoral practice that had grown up under those conditions, was transplanted to the antipodes, far away from any centres of population, where "commerce" was as yet unborn, where the topographic and plant conditions were totally strange and unknown, and where the climatic, soil, and market conditions demanded an agricultural and pastoral practice quite unlike anything they had previously known. To these settlers there was added later another foreign and untried element in the German religious refugees of the 'forties; while there has been throughout the whole period, a further continuous, though fluctuating, addition from the original home islands of Great Britain and Ireland.

The remarkable success that has been achieved by these people and their native-born successors may be regarded as having been accomplished in two ways. Throughout there has been a persistent and tenacious "will to succeed," and success has been brought about by:—

(i.) The mass effort of individual farmers, pastoralists, and others—men of shrewd commonsense and open minds—ever trying new methods, adopting those that were successful, copying from, and being copied by, their neighbours. This movement is represented to-day, in a somewhat wider sense, by the agricultural bureaus and other educational facilities that are encouraged and organised by the Department of Agriculture.

(ii.) In addition, there have been wiser men, men with a broader education or a deeper insight, who have been inspired to invent new types of implements, to adopt new methods of treating the soil, to breed more valuable and better adapted types of both animals and plants, and to make such other important adjustments of agricultural and pastoral practice as have grown into the present general and progressive methods used.

It is not possible to separate these two influences, but the growth of the latter type has manifested itself from time to time in the establishment of definite educational and research institutes. In 1885, notwithstanding the depression that then existed, the Roseworthy Agricultural College was established, and in 1924, under conditions of high prosperity, stimulated by a belief in the value of scientific research and aided by wise bequests, the Waite Agricultural Research Institute was founded.

A further fact, and one of considerable importance, is the extended use made by the State of trained and selected scientific and engineering authorities for administrative work. This we see in the departmental heads and special officers in agriculture, mines, water supply, railways, roads, harbours, forests, education, irrigation, chemistry, architecture, and so forth.

Throughout the history of the State there has been a steady, wholesome, widespread demand for education generally. In 1875, when adverse conditions of low metal prices and low wheat yields had caused a period of depression from which the State was just then emerging, the first important State Education Act was passed; the total population was then about 200,000. In 1892, again a time of depression and unemployment, primary education was made free to all. In 1876, during a prosperous cycle, but with the effects of the closing of the Burra and Kapunda copper mines still in operation, the Adelaide University was founded, and it has rendered profound and incalculable service to the State. In 1915, an Education Act that provided for great extensions of free education was passed, and following on that Act we have seen, during the past decade, a period of exceptional prosperity, a remarkable extension of modern educational facilities closely adapted to the requirements of the people.

The factor of general and special education, as outlined in this section, has played a great part in the adjustment that has taken place, enabling farmers, graziers, vignerons, fruitgrowers, dairymen, and others, under the varied conditions prevailing in different regions of the State (as outlined in Section III.a), to adjust themselves to their varied and varying environments.

Of outstanding importance among the "inventions" were those that enabled man to make better and more immediate use of the light scrub-covered mallee soils, for example: "Mullenizing," the stump-jump plough, and the stripper. There is also the outstanding fact of the adoption of the use of artificial manures, mainly superphosphates, and the development of a local technique in their application to these phosphate-hungry soils; the practice of better methods of tillage and rotation of crops or fallow; the breeding or the introduction of drought-resisting or other special varieties of wheat or other cereals; the breeding of stock more suitable to local conditions or more in demand in the markets; the struggle against plant and animal diseases and pests in farm, orchard, and vineyard; the fight against "seepage" and other difficulties in the irrigated areas; the march of mechanical invention in providing improved transport and communications, and so on. In all these matters, the assistance of specially selected men, highly trained in the knowledge and skill required by such investigations, has been required and has been available. The influence of such factors on population movements has mostly been general, but in some cases the incidence has been specially marked, as has been shown in other sections.

V.—POPULATION GROWTH AND MOVEMENT.

(a) *First Period: 1836-1861.*—The population growth and its distribution during the first 25 years of the State's history is indicated by the spot-map (fig. 7a), already discussed briefly in Section IV.c. In the very early years of our history wheat and wines were grown, cattle and sheep were bred, and copper and

silver-lead were mined. But the preliminary adjustments were not easy, and a marked period of adversity—"The Crisis of 1841"—came in a few years; this has been described by various historians, *vide* Grenfell Price: "Foundations and Settlement of South Australia," Adelaide, 1924, p. 206.

The opening of the first counties, and the discovery of the rich copper fields of Kapunda and Burra led the population outward; railways to the mineral fields assisted, and a prosperous period followed until the lure of the rich goldfields of Victoria (1851), coming on top of a dry period, sent a high proportion of the vigorous manhood of the State to those goldfields. Meanwhile, however, the seasons brightened, wheat yields increased (3,500,000 bushels in 1861), wool export advanced (13,000,000 lbs. in 1861), and mineral wealth continued (Kapunda, Burra, and Wallaroo copper). Over three acres per individual were under cultivation. Towards the end of this period there was a drought.

Fig. 7a shows that, apart from the central counties, there was in 1861 but one West Coast county and two in the South-East. There was a concentration of population in Adelaide itself, and the fertile valleys of the nearer ranges also supported a large number of people. The chief country "islets" were Mount Gambier and Port Lincoln (agricultural and commercial, "capitals" of their respective regions); Kapunda, Burra, and Wallaroo (copper); Gawler (manufacturing and distributing centre, owing to its commanding position at the entrance to the rich Angaston country and the rich arable areas of the lower ranges); Goolwa, Port Elliot, Robe, Port Augusta, and Port Wakefield (ports); Strathalbyn and Mount Barker (agricultural centres).

The areas of practically no settlement are worthy of note. There were but few people along the Murray River, and these were on sheep-runs; none were in the Murray Mallee, and few on Yorke Peninsula, the West Coast, or Kangaroo Island. The last-named area (K.I.) is still but sparsely populated, but the other three regions have since become productive provinces.

Up to 1861 only one long railway had been built, that from Adelaide to Kapunda. Roads were few, and transport slow. There were no reservoirs or other organised scheme of water supply, each settler being dependent on his own efforts with tanks, dams, and wells. Apart from the strong pull of the mineral fields, the chief population movement was towards the South-East, and along the rich alluvial inter-ridge plains of the Lower North.

(b) *Second Period: 1862-1871.*—The population *movement* for this decennial period is shown in fig. 19a. The population for 1861 (fig. 7a) was the *total* at that date. From now on the population maps deal with the *movements* only, that is, with the number of people *added* or *lost* by each county during each decennial period.

As shown in fig. 19a, several new counties had by the year 1871 been added to those of 1861—to the north, east, and south-east. There was much additional concentration in County Adelaide; also towards the mineral centres of Kapunda, Wallaroo, and Moonta, the last-named having been discovered in 1861. There was a drift away from the Burra copper mines, noted by the circles (each equal to a loss of 100 persons) of County Burra. County Victoria had also lost 300 settlers; but there was a strong growth in the main central counties, and in the South-East, with a minor movement to the north as far as Hawker, to the West Coast, and also to lower Yorke Peninsula. The Murray Valley and the Murray Mallee remained practically untouched.

The seasons of this decennial period were generally good, but 1866 was dry. The good rains of 1867 did not bring equivalent yields, as red rust attacked the wheat crops. The stump-jumping plough had been introduced. More country had been thrown open, but this period ended in depression, with loss of popula-

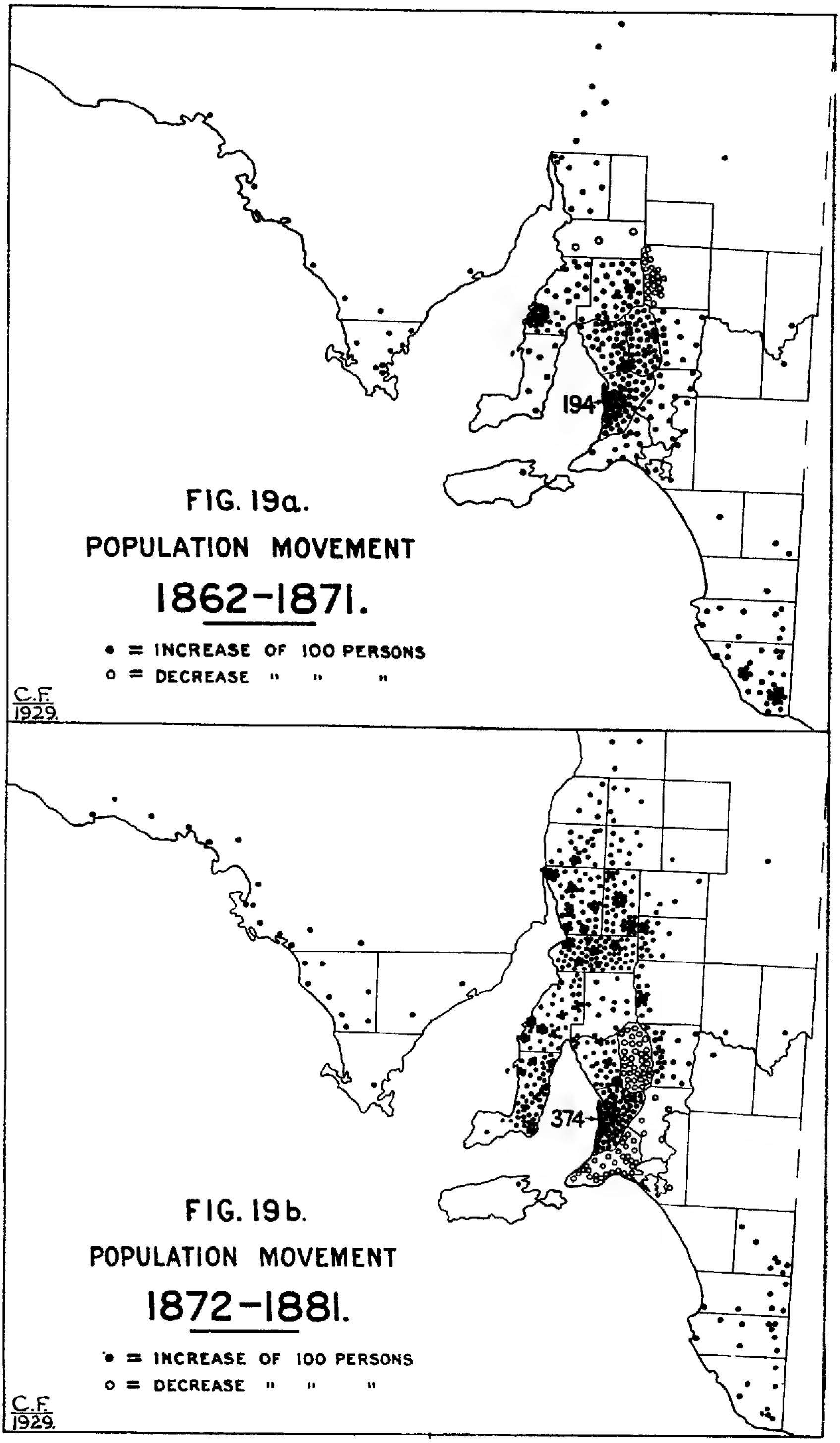

194
FIG. 19a.
POPULATION MOVEMENT
1862–1871.
● = INCREASE OF 100 PERSONS
○ = DECREASE " " "
C.F.
1929.
374
FIG. 19b.
POPULATION MOVEMENT
1872–1881.
● = INCREASE OF 100 PERSONS
○ = DECREASE " " "
C.F.
1929.

Fig. 19.

tion, possibly due to a considerable extent to the prevailing low prices for copper and to poor wheat yields.

The concentration of population in the metropolitan area had led to the need for various community services. Water was laid on in 1861, and gas in 1863. The city, which in 1871 contained about 30% of the total State population, thus began to introduce factors that assisted towards an increasing concentration there, owing to the comforts and amenities available. The chief "pull" of Adelaide, has, however, been that of available employment. A railway line had been carried on to the Burra copper mines, but there was still no provision for country water supply, no organised wheat transport, few ports, no special wheats nor artificial manures in general use.

(c) *Third Period: 1872-1881.*—This period, as shown in fig. 19b, showed the usual more intense concentration towards the metropolitan area, which, in this case, added 37,400 people to its total population. Apart from minor but very significant movements towards the South-East and the West Coast, the marked progress of this decade was towards the rich wheat areas lying east and north of Port Pirie. Even the most distant of the new counties to the north had attracted settlers, but some of these movements show evidence of an excess of zeal. The counties of Taunton, Derby, and Lytton (all proclaimed in 1877) should never have been thus set apart for closer agricultural settlement. They are almost wholly outside of the 10-inch rainfall line, and the efforts of 50 subsequent years have emphasised their unsuitability for agriculture. In some cases, as has been remarked, settlers ploughed up good sheep feed (salt bush) to plant wheat that would not grow.

The second great "trek" of this period was towards southern Yorke Peninsula, brought into prominence by the discoveries of copper in the north of this region. The chief negative movement, shown in fig. 19b, was in County Light, and was due to the closing of the copper mines there in 1878. The Burra mines, also, which had been waning for some time, finally closed down in 1877. County Sturt, to a lesser extent, and County Hindmarsh most markedly, showed drifts of population. This was doubtless due to agriculturists and pastoralists who were not doing as well as they wished moving out to the greater spaces and the wider opportunities of the northern wheat lands. In 1875 the first Forest Board was constituted.

During this decade the proclamation of counties (figs. 4 and 5) was at its zenith, but the average annual rainfall over the whole area proclaimed (nearly 20,000 square miles) was little more than 10 inches per annum.

In spite of some adverse seasons, the position of the State was good; the population gradient in 1881 was high; cultivation was extending very rapidly; superphosphate manures were introduced about 1880; the number of sheep, cattle, horses and pigs had almost reached the total at which they stand to-day; the city had its second reservoir (Hope Valley). There was most interesting additional railway extension during this decade. Quite a number of small outer ports were favoured with lines running inland: Port Wakefield—Hoyleton, Port Pirie—Crystal Brook, Kingston—Naracoorte, Moonta Bay—Moonta, Port Wakefield—Kadina, Port Augusta—Quorn, Beachport—Mount Gambier. From the railway point of view, the period marked an effort towards decentralization.

(d) *Fourth Period: 1882-1891.*—Fig. 20a shows the changes that took place in the next decennial period. Opening under the influence of the prosperous years of the preceding decade, this cycle closed with one of the most severe periods of depression ever experienced by the State. New country was available, but the methods of attacking, particularly in the more outback areas, had not been perfected sufficiently to ensure stability there. Superphosphate manures had been

introduced, but their adoption was slow, and only a small percentage of wheat farmers had so far utilized them; even at the end of the next following decade (1900) only about 25% of the farms used phosphatic fertilizers.

During this period five new counties were opened; all were on the West Coast, distant from markets and railways, with the exception of Manchester. But the last-named county is practically wholly outside of both the 10-inch rainfall line and the 8-inch winter rainfall line. Even after 39 years, it is to be noted in the current wheat yield records that Manchester is practically a non-producer so far as agriculture is concerned. Like Taunton, Derby, and Lytton, Manchester appears to be a mistake on the side of optimism. The whole of the areas proclaimed in this decade averaged less than a 10-inch rainfall, but four of them (Robinson, Dufferin, Way, and Kintore) are wheat producers.

The opening years of the decade were dry, being classed as a "disastrous drought" in some regions, and as low rainfall in all. During this period the Adelaide rainfall was below average for six of the ten years, and this is a reflection of the general position throughout the whole State. The population curve during this period showed a distinct flattening; during three years (1885-6-8) there was actual decrease. The proportion of cultivated land also fell, and in 1891 the total was less than it had been in 1882 (fig. 6).

The flocks and herds decreased, though the cattle recovered earlier—about 1891. It was probably under the stimulus of these dry years that the Mount Gambier pumping station was established, the small Hawker reservoir (in the most northerly of the wheat areas), and the first big country reservoir (Beetaloo) were constructed (see figs. 13 and 14). Thus this driest of all the decades saw, and possibly brought about, the opening of the present great water reticulation scheme.

The period of depression not only stimulated the water schemes, it also influenced the transport system. In spite of a falling population, these years witnessed one of the most rapid periods of railway extension—in the central and northern wheat areas, towards Oodnadatta, to Melbourne (the first link with another capital city); under the stimulus of the rich Broken Hill silver-lead-zinc field, the valuable and productive Port Pirie—Broken Hill line was built, that is, the existing Port Pirie—Jamestown line was continued to Cockburn along the Olary Spur of the Central Highlands. During this period, also, there was a marked extension of main road mileage, and important road acts were passed.

Under very difficult climatic conditions, super-imposed on lack of facilities for water, transport, etc., the Broken Hill silver-lead mines were opened in 1884. Geographically these belong more to South Australia than to New South Wales, and their nearness, combined with the more powerful influence on man's imaginations that is always exerted by mineral fields compared with agricultural "fields," caused a dramatic "rush" away from South Australia. Population flowed away from the State, comparable only with the exodus to the Victorian goldfields in the 'fifties

Within the State itself a population movement set in towards Port Pirie and Wallaroo; Adelaide continued to grow (Broken Hill brought much trade and wealth to Adelaide, though it temporarily drained this State of people); people continued to move towards the northern areas and the West Coast (see fig. 20a). The first great negative population effect was felt in the Central districts; Counties Gawler, Light, Burra, and Stanley lost population to a marked degree; farmers left the fields of Yorke Peninsula, and two of the lesser counties bordering the Murray also showed losses. Even the wetter counties between Mount Gambier and Bordertown lost population; perhaps due to a movement north towards the new Melbourne—Adelaide railway line.

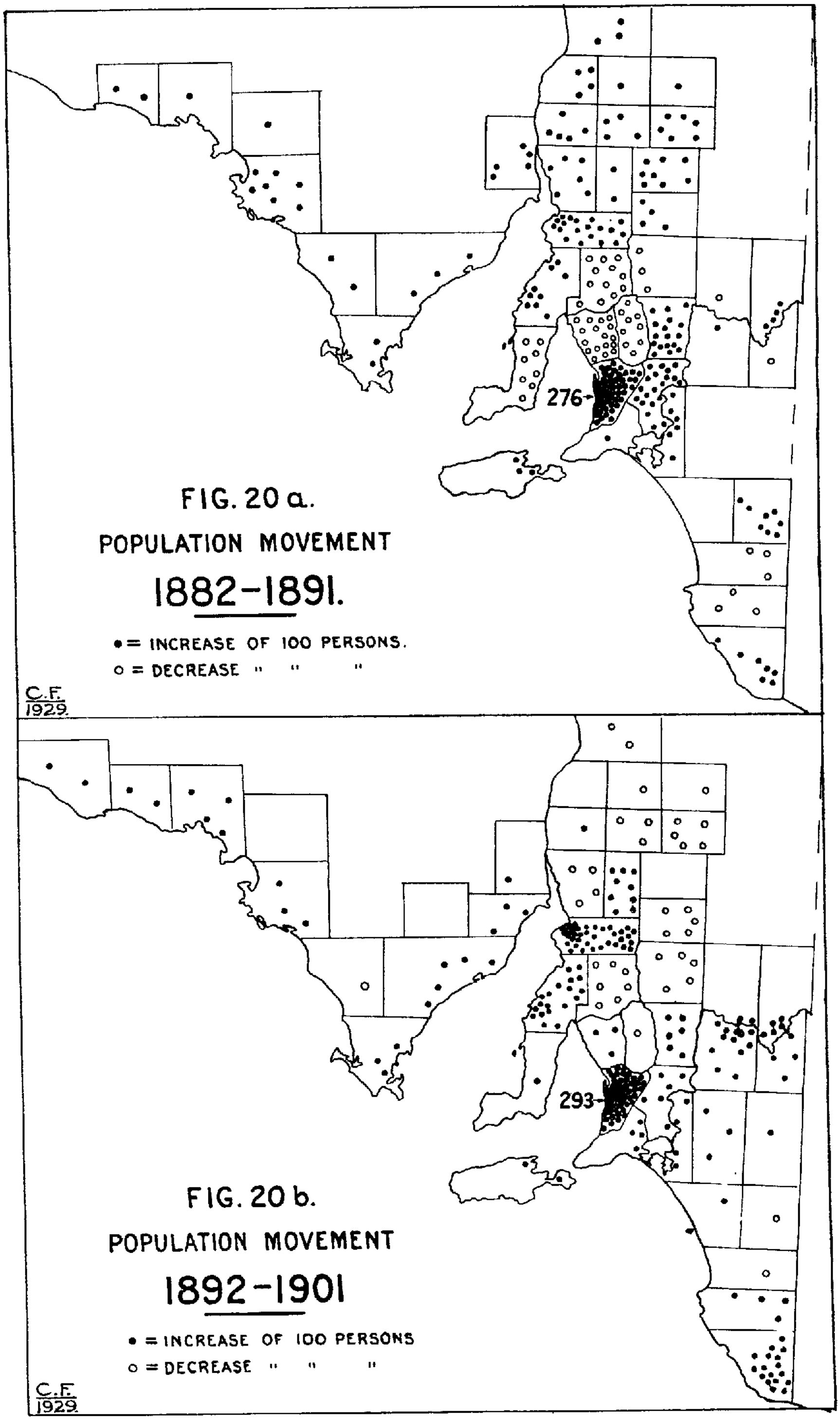


FIG. 20 a.
POPULATION MOVEMENT
1882–1891.
• = INCREASE OF 100 PERSONS.
○ = DECREASE " " "
276
C.F.
1929
FIG. 20 b.
POPULATION MOVEMENT
1892–1901
• = INCREASE OF 100 PERSONS
○ = DECREASE " " "
293
C.F.
1929

Fig. 20.

Altogether the decade 1882-1891 was a remarkable one. It was a period of difficulties and depression, combined with the stimulating effect of the riches of Broken Hill. But, as we have seen, these climatic and other difficulties also proved a stimulus in at least four directions, all of which combine to enable us to-day to meet drought conditions with more confidence. These four directions were: (a) More fertilizers and better tillage (agricultural bureaus were established); (b) Transport (road and rail); (c) Water supply; (d) Irrigation. During this period the pioneer irrigation area of Renmark was established by private enterprise in the Murray Valley.

(e) *Fifth Period: 1892-1901.*—The years of this decade were also difficult ones in South Australian progress. The reforms that had slowly grown up during previous years continued to extend but slowly. Difficulties of climate, topography, and distance cannot be conquered in a decade. It took men a long time to learn that they might take advantage of dry conditions, rather than deplore them, while at the same time endeavouring to overcome them. The value of the summer drought for wheat-ripening and harvesting, fruit drying, salt producing, etc., was not at once realized.

Five new counties were proclaimed—two in the southern Murray Mallee, two in eastern Eyre Peninsula, and one in the distant western part of that region (see figs. 4 and 5). The population graph took a slight rise and later flattened, but there was no year in this decade when the number of people in the State actually decreased. The area of cultivated land rose definitely in 1899-1900. The Adelaide rainfall was low throughout this period, and there was a drought about 1896. County Adelaide and the metropolitan area, with its growing industries and with the benefits of water, gas, transport, and good climatic and soil conditions, expanded faster than did the country districts, while the coming of electric light and power in 1900 gave the city an additional advantage.

The success at Renmark had attracted attention, and in an effort towards a solution of the unemployment problem a series of "Village Settlements" was established in the Murray Valley. These are generally regarded as complete failures, but they were a success in directing attention to the potentialities of the Murray Valley, in pointing out the difficulties that were to be faced, and in the start thus made towards devising methods for overcoming these difficulties. Throughout the decade the sheep decreased by millions and the cattle by hundreds of thousands (see fig. 11); the losses in flocks and herds were the greatest the State has known, apart from the 1914 drought period.

One large metropolitan reservoir was built during this decade, and two small country ones; the length of mains was much increased, and preparations made for new country water storage basins. The extension of railways practically ceased; it was as if the country was exhausted by the tremendous efforts in railway extension of the previous decade (including the costly and unproductive Oodnadatta line), and for some years railways were left severely alone. The period was equally unprogressive so far as road building was concerned.

Right in the middle of this difficult period the world was moved by the spectacular mineral discoveries of the Western Australian goldfields. South Australians were near the spot, they were acclimatised in part to that type of country, their State was still suffering from the depression caused by dry seasons, and they were men of adventurous stock. The third great exodus from this State set in to Western Australia in the middle 'nineties (the first was to Victoria in the 'fifties, the second to Broken Hill in the 'eighties). Another drain on the population, and one of a kind hitherto unknown, was made by the South African War in the late 'nineties.

The map of internal population movement (fig. 20b) shows that there was a decrease in no less than thirteen counties. There was continued movement

towards the South-East, a slow but sure development along the West Coast, and a considerable influx into the counties that contained the mining and smelting towns of Port Pirie and Wallaroo-Moonta. In 1900 gold was discovered at Tarcoola, well outside of the counties, and this locality has continued to produce mineral under very difficult conditions up to the present time. Meanwhile, throughout the State, the leaven of better farming practice, of the use of superphosphates, of transport, and of water supply were being felt, and the way was being prepared, not only for wider prosperity but for greater powers of resisting and even overcoming dry conditions within the 10-inch line. The problems outside (north of) the 10-inch line remain almost as difficult to-day as they were then.

(f) *Sixth Period: 1902-1911.*—With the opening of the new century the Province of South Australia became merged into the greater political unit of the Commonwealth of Australia, but agriculture, transport, water supply, etc., remained as functions of the State. Whether the facts are those of cause and effect one cannot say, but apart from the Great War and the 1914 drought, the years since Federation have been the most consistently and steadily prosperous since the foundation of the State. It seems clear that the people of South Australia are enjoying the cumulative effects of the adjustments man has made with his environment during the preceding seventy years of settlement.

As far as land occupation is concerned, the limit of agricultural occupation had been reached by the end of the last century. Since 1900 only two counties (Le Hunte and Bosanquet, in central Eyre Peninsula) had been added, and the whole of the over 10-inch rainfall land had been proclaimed as counties (see figs. 1 and 3b). There is, indeed, a relatively small area of 10-inch land not proclaimed, but it has disabilities of roughness of topography and of remoteness that discount its other advantages.

In the first year of this decade occurred the drought of 1902, and with it came the first actual population reduction since the 'eighties. Possibly there had been seasons before that were just as dry, but there was not then the wide area of lower rainfall land occupied. In spite of this great set-back, accompanied by considerable emigration of its young manhood (in 1902 the State decreased by 7,000 of its most vigorous inhabitants, quite apart from deaths), there was a general upward movement of the total population, and this was accompanied by an extension of the cultivated areas. By 1910 there were 10 acres of cultivated land per individual, the highest since the foundation of the State, and approached only in 1880, thirty years previously (see fig. 6). The country population was, for this decade, increasing faster than that of the city.

The use of manures and improved methods of farming were making themselves felt (see fig. 9). Not only were the total yields of all crops increasing, but the average yields were also noticeably rising. Cattle, sheep, and horses increased by nearly 50%, thus:—

	1902.	1911.
Sheep	4,880,000	6,172,000
Cattle	213,000	394,000
Horses	165,000	260,000
People	357,000	419,000

This wonderful power of recovery after a severe set-back is characteristic, and is revealed again and again in the records of South Australia.

Some amount of industrialization had now entered into the life of the State. There had been for some time the mining centres of Moonta and Wallaroo Mines, smelting ports such as Port Pirie and Wallaroo, railway towns such as Peterborough and Murray Bridge, and engineering towns such as Gawler, Kapunda, and other smaller places where agricultural implements were made.

The increase of factories in the metropolitan area now began to be notable; most of them were concerned with the provision of local requirements, but some were also producing manufactured goods for export. The production of salt had increased, and gypsum now became an important product. The line to Iron Knob was built in 1901, but this immensely rich deposit of iron ore was at first used only in connection with the smelting works at Port Pirie.

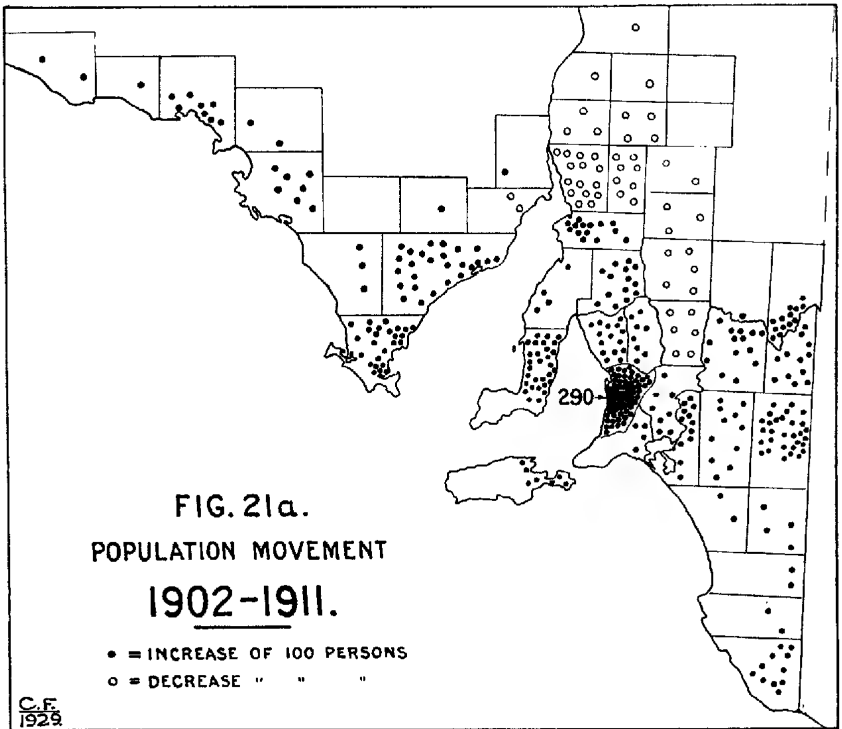
There was considerable progress in the provision of country water supplies in this decade; Barossa and Bundaleer reservoirs came into operation following the 1902 drought, and over 1,000 miles of water mains were laid (fig. 14). The fertile flats and "swamps" of the Lower Murray Valley came further under notice, and a most important movement dates from 1904 when a scheme of State Irrigation was commenced. The Outer Harbour, built near the mouth of the Port River, where engineering skill has utilized to the full the few advantages provided by the type of coastline that borders the Adelaide region, was opened in 1904.

Little railway extension took place, but the call of the light soil plains of the Murray Mallee and the West Coast began to be heard; a line from Tailem Bend to Pinnaroo was built in 1906, and from Port Lincoln to Yeelanna in 1907-9. This was the beginning of the addition to the State of two valuable but hitherto unproductive areas, though for years settlers had been tenaciously working their way along the West Coast margins. Motor cars appeared on the roads, but were not yet of great importance; the mileage of main roads was increased.

The population movements of this decade, shown in the map (fig. 21a) are the most remarkable to date. They bear witness to the zenith of the rise of the wheat lands. Hundreds of people were added in each of the chief counties of the West Coast. Yorke Peninsula, whence in the 'eighties the people had been streaming away, increased notably. Even the already well-settled central regions (Counties Victoria, Stanley, Gawler, and Light) were considerably added to, while the Murray Mallee now began to be properly opened up. The usual concentration in the metropolitan area continued, somewhat further accelerated by the influence of the electric trams, 1909, (providing work), and the increase of factories; during the decade 29,000 people were added to the County of Adelaide. There was, however, an extraordinary decline in the population of the northern and north-eastern counties, from Taunton southward to Eyre (see fig. 21a); this amounted almost to a wholesale flight of the population away from the conditions experienced in the 1902 drought. But it is satisfactory to reflect that the men who had learnt the hard lessons of these northern counties were largely those who went out into the new wheat lands, equipped with ability to cope with the special conditions there, and thus to achieve the marked success that has followed.

(g) *Seventh Period: 1912-1921.*—This decade, which was on the whole one of general prosperity, is the most difficult to describe of all the periods of State progress. In it occurred the record drought of 1914 and the record good season of 1916. During this period, also, the Great War blazed up in Europe, the springs of emigration to South Australia were dried, and the most vigorous portion of the manhood of the State was poured out, literally in tens of thousands, to the battlefields of the Old World. The whole outlook of the State was temporarily changed, and the depression that was caused in some directions was offset by the extraordinary stimulus in other directions caused by war conditions. Following the declaration of Peace in 1918, came the almost equally stirring and disturbing years of Demobilization and Repatriation, so that it was many years before the people of the State got back into the even step of normal production.

The effect of the war on the general increase of population is shown in figs. 6, 8, and 22. The demand for wheat greatly increased, and prices were high. In spite of the absence of so many men, and notwithstanding the effects of the 1914 drought, the amount of cultivated land reached an extent never previously


290
FIG. 21a.
POPULATION MOVEMENT
1902-1911.
• = INCREASE OF 100 PERSONS
o = DECREASE " " "
C.F.
1929.

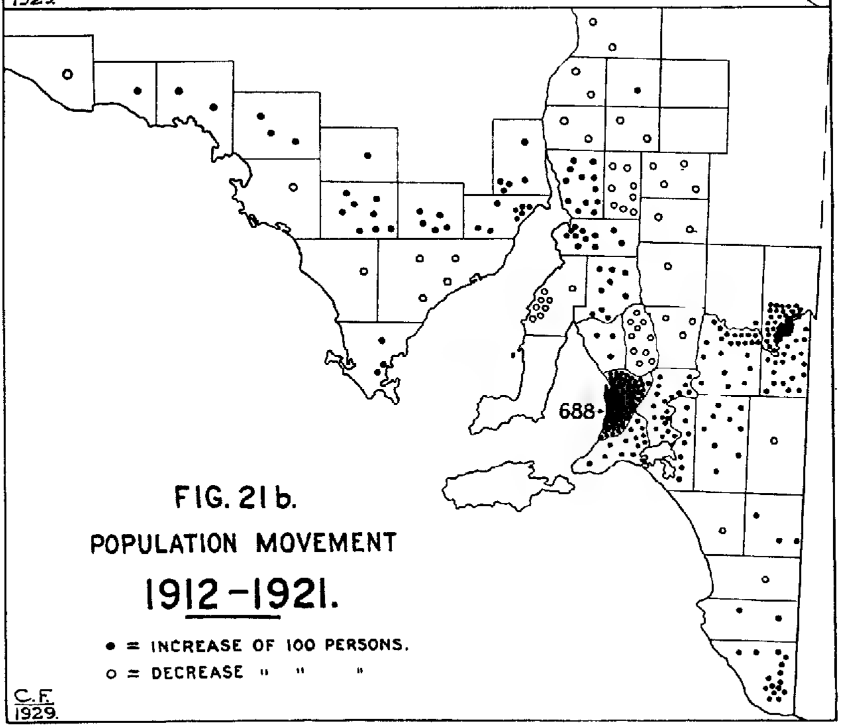

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FIG. 21 b.
POPULATION MOVEMENT
1912-1921.
• = INCREASE OF 100 PERSONS.
o = DECREASE " " "
C.F.
1929.

Fig. 21.

approached, though there was a rapid temporary decline in 1919 (a dry season). The total increase of population was large, and after the war the city grew much more rapidly than the country, and faster than at any previous period.

At no time has there been such an extraordinary variation in wheat production within the space of three years as is shown by the Government Statist's records in fig. 9 (1914-1917); other crop yields suffered similarly, and showed a somewhat similar recovery. The compulsory "bare fallow" of the drought year (1914) was one of the factors influencing the great production of 1916-17, but high prices, superphosphates, more machinery, and better farming methods also contributed. The graphs of the varying numbers of livestock for this decade are like huge V's, dropping down towards 1914, and rapidly rising to 1922 (see fig. 11).

There was a marked increase in factory production, not so much in the number of men employed, but in the materials and horse-power used (see fig. 12). Pumping schemes along the Murray were instituted; the largest of our metropolitan reservoirs (Millbrook) was built; Warren and three lesser reservoirs were added to the country system, and the water mains were extended by some 1,400 miles. The second great period of railway extension took place in this decade (fig. 16), in the construction of the Murray Mallee and West Coast lines. The use of motor power on the roads increased, and encouraged the production of more and better roads. This provides an excellent example of the way in which geographical factors re-act upon one another. More motor cars demanded better roads, and the provision of such roads encouraged the further use of motor cars. So it is with water supplies, railway facilities, etc.

The map (fig. 21b) showing the internal population movement, while not so stimulating as that for the previous decade, is still full of vitality. There is a population decrease in sixteen counties but, except in one case, to be discussed later, it is not disturbing. The decline of the Wallaroo-Moonta copper field necessitated a loss of population there; some settlers from Southern Eyre Peninsula had moved outwards or to the north; the lower rainfall counties of the north and north-east have further declined, and there is somewhat of a stillstand as a whole in the central portion of the South-East, between the Murray Mallee and the Mount Gambier district. County Adelaide has increased by nearly 70,000 people. The export of Iron Knob ore for steel-making (1914) resulted in the creation of two new townships (Iron Knob and Whyalla). The most promising movement shown in the 1912-21 decade is that along the Lower Murray Valley, where, partly stimulated by the repatriation movement and partly by the creation of the State Irrigation Department, several thriving fruit, vine, and dairying towns and villages came into being.

The more disturbing decrease of county population above referred to is that of County Light, where, in an area of excellent soils, settled farms, good and reliable rainfall, satisfactory water supply, and a good road and railway system, there is a population decrease of 1,000 people. In so fertile and favoured an area an increase might have been anticipated. With a knowledge of this county gained in over fifty years of intimate contact with the people, Mr. H. J. Truscott, a resident of Kapunda, has kindly set down his opinions, at my request, regarding the reasons for the diminishing population of County Light. These may be taken as the average opinion of thoughtful men living in the country districts, and are as follows:—

"I must endorse your remarks that the county, as a whole, is a fertile and well-watered area, and under ordinary conditions should have increased its population rather than decreased. The cause of the decrease has been mainly due to the purchase of small holdings by the bigger landowners, thus dislodging a large number of families that have gone elsewhere to earn a living. The argument is

that farming on a small scale does not pay. Owing to the high price of implements and other appointments necessary for successful farming, the small man is outclassed and the big man with larger areas and up-to-date machinery gains control of the land. Lands offering outside of settled areas in our own State, and especially in Western Australia, have induced a large number of young people to leave their own country for other fields, establishing new homes and new families in other parts of the Commonwealth. The city, with its up-to-date facilities, attractions, and variety of occupations draws the younger generation to its centre, and a number of young people, when reaching their majority, have gone to Adelaide or other centres of greater opportunity. Apart from the working of the land, and the harvesting of the products of the soil, our resources are limited, and there is not much scope for employment, or for the maintenance of a growing population. The ordinary blacksmith's shop is engaged in repairs, there is little new work. Grocery and other stores are just holding on, handicapped because of limited patronage. The motor car and motor traffic have taken away rather than improved local business. Agents from the city, representing firms of every description, are pressing one upon another. Private persons who own cars, especially farmers, go to the city to purchase, and in this way local business people are affected. The facts that I have mentioned are without doubt the cause of the decrease of population in the County of Light, and there appears to me to be no hope of an improvement, so far as secondary industries are concerned. I feel, however, that there is room for improvement in matters pertaining to the land. Closer settlement is required. There is too much land locked up for sheep and cattle grazing. I think that measures should be introduced that would make it hard and expensive to hold thousands of acres of good land as mere grazing area, when such lands could be used for the maintenance of a much larger population."

Whenever one travels throughout the older settled districts of the Australian States, one may occasionally note the presence of ruined houses, old wells, neglected orchards, solitary chimneys, disused roads, and other similar evidences of human culture in localities where at the present time homes are rare.

In some cases enquiry reveals this somewhat depressing feature to be a part of the ebb and flow of population that is continually taking place—often associated with the fact that families grow up, the young people move away, the old people die, the farm is bought and used for less intensive agriculture, and the home is no longer occupied. In other cases, agricultural districts have thrived because of the nearness of markets provided by mining towns, and with the closing of the mines there has been a natural falling off in the farm values of the neighbourhood, with consequent emigration.

While this apparent decay of country life is notable in County Light, as shown above, and in almost all the older settled districts of the Commonwealth, it is not unknown in other parts of the world. Some excellent detailed studies have been made in the United States of America. One of these, which is of particular value and interest, was written by Professor Goldthwait, of New Hampshire, U.S.A. (*vide* "Geographical Review," October, 1927, p. 527-552).

In this is shown, in an almost dramatic way, the ebb and flow of population in a New Hampshire locality. The disturbing influences that are noted particularly in the study are (1) the concentration due to the rise of manufacturing centres with good work and pay; (2) the routes of new railways, changing the relative positions of markets, etc.; (3) the movement westward towards larger farms, cheaper land, and better opportunities.

Although the general geographical conditions in New Hampshire are very different from those in South Australia, the influences of these three factors may be distinctly noted in our own State. The coming to country dwellers of such

amenities as quick and comfortable transport, telephones, wireless, etc., does not appear to have greatly arrested the movement from country to town, which is so marked a feature of later population movements of this State.

Eighth Period: 1922-1927.—This, the final period, comprises six years only, and no special map has been prepared to show the population movement during that time. Special care, however, has been taken in the preparation of fig. 7b, which shows the total population for 1927, and its distribution. Compared with the population map of 1861 (fig. 7a), the 1927 map gives us the "end product" of all the internal population movements for the intervening decades. The character of this map, and the geographical reasons for the distribution of the population of 1927, as shown, have been the guiding *motif* throughout this paper, and were discussed in some detail (particularly so far as the "islets" of people are concerned) in Section IV.c.

These six years have constituted a period of general prosperity, ending on a somewhat lower note on account of the incidence of dry conditions and unemployment. Not only have the yields of these years been high, but prices have been good. The extension of counties has ceased, and the fact is coming to be generally recognised that future progress must be made within the areas already proclaimed.

The total population has increased during this period at a rate hitherto unapproached, except in the years just preceding the war. The city increase is the more accelerated, which may, in part, be correlated with the increase in city amenities and with increased public works and manufactures (fig. 12); indeed, as the writer has already shown (Proc. Roy. Soc. S.A., vol. li., 1927, p. 250) the rate of country growth is at present notably low.

The total acreage of cultivated land is higher than it has ever been, and the proportion of cultivated acres per inhabitant is also at a maximum. The yields of all crops are higher than for any previous period (fig. 9); the present distribution of the wheat areas is shown in fig. 10. So far as flocks and herds are concerned the position is not good, as already mentioned. In many cases these are decreasing, and altogether the total average numbers have not shown any increase for the past 40 years (fig. 11). In 1927 the forest reserves of this relatively timberless country amounted to 200,000 acres, of which some 40,000 acres were planted, half with introduced softwoods and half with planted or regenerated native hardwoods. The State has achieved some prominence in its successful growth of softwood forests.

In the realm of water supply two large country reservoirs have been added, and the general increase of reticulation has been the most rapid and extensive of the whole history of the State, as is shown in the graph in fig. 14. There has been little development in railway mileage, though narrow-gauge lines (3 ft. 6 in.) have been widened (5 ft. 3 in.). Just as the stage-coaches and canals fought a battle with the railways a century ago, so are the railways at present competing with road-motor transport. This is accompanied by a slowing down of railway extension and an accelerated construction of high-grade roads, with a remarkable increase in the number of motor vehicles (fig. 17). The general population movement of 1922-1927 may be gauged from a study of fig. 7b. People are moving about more, and more rapidly than they used to do; settlement tends to concentrate more into cities and larger towns; yet, on the whole, there is a thoroughly healthy dispersion steadily going on towards the further settlement of (a) the Lower Murray Valley, (b) the West Coast, (c) the South-East, and (d) the Murray Mallee. What Yorke Peninsula lost in the closing of the copper mines of the north it has gained in the barley fields and the salt and gypsum deposits of the south, but more particularly in the stable settlement of its rich wheat areas.

VI.—FINAL CONSIDERATIONS.

(a) *Births and Deaths.*—Among the conclusions reached in the study of these ebbs and flows of population and industry and general progress during the period 1836-1927, it becomes increasingly certain that amid all these fluctuations, one of the most stable and important factors of all is to be found in the total annual births. The curve of these figures shows a steady growth from the beginning, reaching a peak period in 1885. In the twenty years of depression that followed, births decreased somewhat; indeed, both the birth-rate and the death-rate show a definite but minor response to the onset of hard conditions, with a more recent gradual decrease that is well known and is part of a world-wide tendency.

When we come to consider what is called the natural increase of the State, *i.e.*, the excess of births over deaths, we find a curve that is even more regular and stable. It rises gradually to 1885, remains firm and steady to 1895, decreases in 1898, and rises again to a maximum in 1914. Thereafter it is even and regular, apart from a dip in 1919 due mainly to the unexpected excess of deaths consequent upon the influenza epidemic of that year. This curve is not the wavy, fluctuating line that we get from almost any other set of State records. It is regular, stable, and dependable. It is significant of the best type of State growth, and is full of promise for future development.

(b) *Immigration and Emigration.*—Among the most unstable curves that we may obtain from presenting in a graphic form the figures available in statistical returns are those of the additions to, and subtractions from, the total State population by immigration and emigration, respectively. In the beginning, all population gains were by immigration. Subsequently there have been periods of almost equally rapid growth from this source. The figures of immigration and emigration, however, as compiled in statistics, are of little value. From their nature they are not reliable, sometimes including all those who entered or left the State by rail or boat, at other times only those with single tickets, and so on; immigrants and emigrants are not separable from the ordinary flow of tourist and business traffic. It was necessary, therefore, if definite figures regarding the addition to our growth from without were to be compiled, that other methods must be used to obtain such figures.

(c) *The "Prosperity Graph."*—It was thought that a curve roughly indicative of the varying prosperity of the State could be drawn if we knew the total number of persons each year that were added to the permanent population, having been attracted from without the State. The basis of this belief is as follows:—If within the State the general conditions are thriving, work abundant, the land productive, and the people prosperous, the influence of this prosperity will automatically and inevitably show itself in the power of the State to attract adventurous and enterprising people from other countries. But if, on the other hand, conditions are bad, crops poor, unemployment marked, and financial conditions relatively adverse, there will not only be no increase from without, but some of our own people will leave us (among them the strongest and most enterprising) to seek better conditions elsewhere. Under normal and average conditions, neither notably adverse nor prosperous, we should be able to hold our own, to absorb our own native-born, without either gaining more than these, nor losing.

If, then, we obtain the total *increase* of the population of the State for each year, as compiled in our statistics, and subtract from that number the excess of births over deaths (the internal natural increase), we shall know the total numbers added to our population each year from outside sources (or, in adverse years, the total numbers lost by the State). In the prosperous years this increase by immigration would go up, but in the bad years, when the prospects elsewhere seemed to our own people (or to a sufficient proportion of them) brighter than those within the State, there would be a movement outwards—an exodus.

On this foundation, and with figures specially compiled from the "Statistical Summary," the curve which is here called the "Prosperity Graph of South Australia, 1836-1927," (figs. 22a and 22b) has been constructed. It will be seen that in prosperous cycles of varying length we have alternately received and absorbed tens of thousands of people additional to those born here, or in periods of adverse conditions we have poured out some of our best and most vigorous people (for only these more plucky and adventurous ones face the uncertainties of emigration), and have thus been for a time a centre of emigration, and not of immigration. On this graph the chief factors influencing the progress or retardation of the State have been indicated. It is agreed that no single factor can justly be regarded as giving a true index of prosperous and adverse conditions.

As a check on the value of this so-called Prosperity Graph, a curve was constructed, based on the Government Statist's figures for the whole period 1836-1927, dealing with increases or decreases of sheep, cattle, horses, wheat yields, cultivation, rainfall, and other more generally accepted indicators of prosperity. The general similarities between the trends of such a curve, and that of figs. 22a and 22b, were quite considerable, with a satisfactory degree of correlation, justifying the belief that the prosperity of the State can be generally appraised according to the population it may attract or expel. When prosperous, the State will not only absorb its own native-born population, but will attract some from other countries; when conditions are adverse, not only will there be no external addition, but the native-born or acclimatized population will be driven to seek livelihoods in outside areas. In the "Prosperity Graph" (figs. 22a and 22b) the vertical columns for each year that are *above* the normal line represent in thousands the permanent population additions from without. The vertical columns *below* the normal represent definite losses from the State. On the whole, the years of prosperity are those where the curve is rising, or maintaining a high level. The adverse years are those with a declining curve or a sustained low level, but in all cases some allowance must be made for a "lag" between the influencing factors and the adjustments thereto.

Apart from the abnormal conditions of the war and demobilization (1914-1919), and disregarding the natural increase due to excess of births over deaths, the greatest annual increment to the population was in 1849, when there was an addition of over 12,000 people. Other high records were 1854 (11,500) and 1876 (10,000). The years of maximum population loss were 1885 (over 9,000) and 1856 (9,000). The cycles of relative prosperity and adversity are suggested in fig. 22. It is, on the whole, a record of advancing prosperity, based on agricultural and mineral wealth, with minor depressions, until the year 1866. There followed an 8-year period of heavy depression (low wheat yields, in part low metal prices). A prosperous cycle followed up to 1881. In 1884, as already described, a long series of less satisfactory seasons and unfavourable conditions commenced, emphasized by the permanent loss to Broken Hill and to Western Australia of tens of thousands of the best of our manhood.

This long era of State depression (which may or may not have been a period of individual financial depression), with lesser breaks, reached on for more than 20 years, right up to 1905, when the tide which had been preparing to change definitely turned in the direction of State prosperity. From 1908 onward for over 20 years, despite the war of 1914-18 and the drought of 1914, and influenced by various artificial factors of legislation and finance, the cycle has been one of high prosperity, population increase and extension, and the adoption of a continuously higher standard of living and of comfort in both metropolitan and country areas.

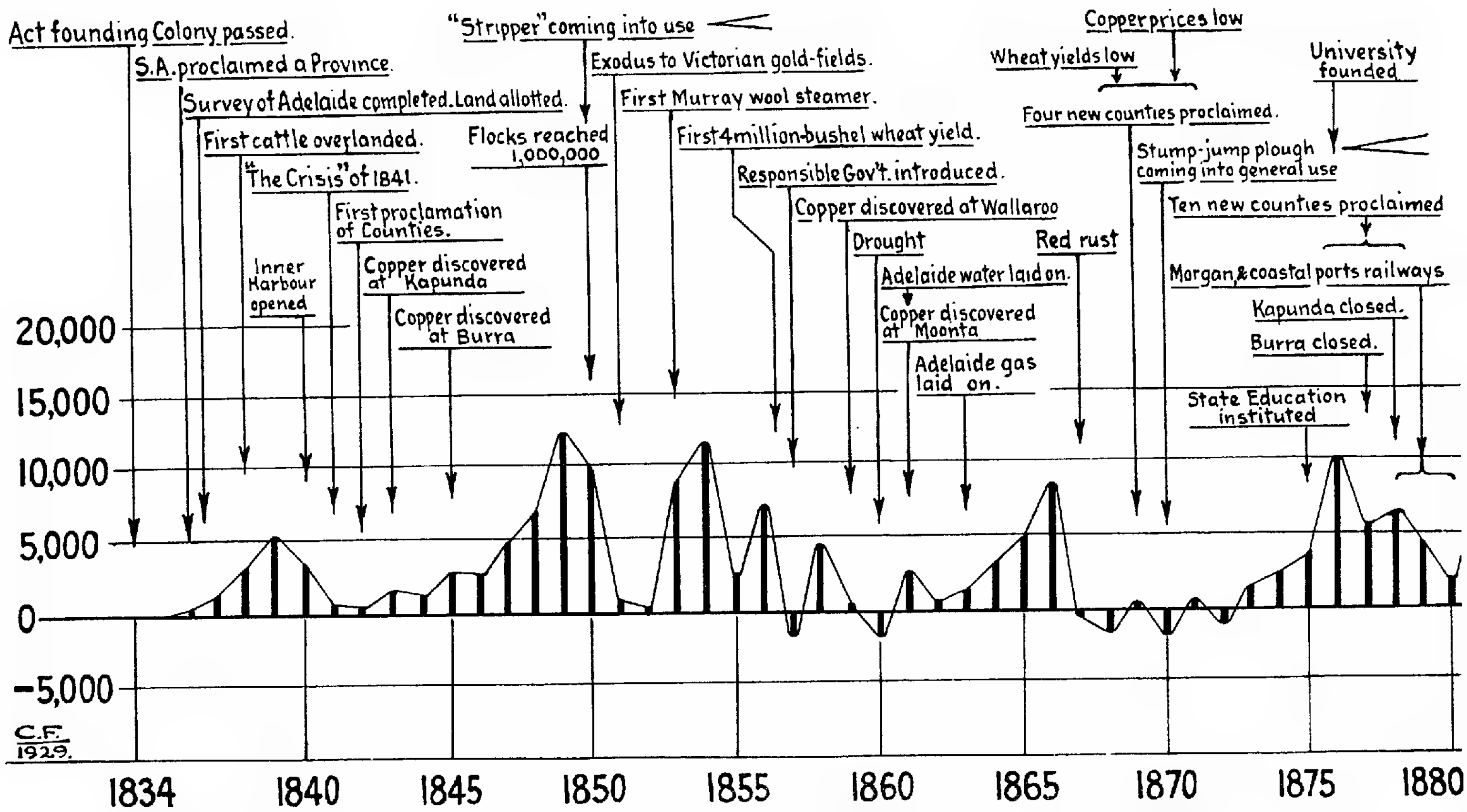

Fig. 22a. The "Prosperity Graph" of South Australia,—really a curve showing the yearly excess of Immigration over Emigration, or the reverse. With annotations.

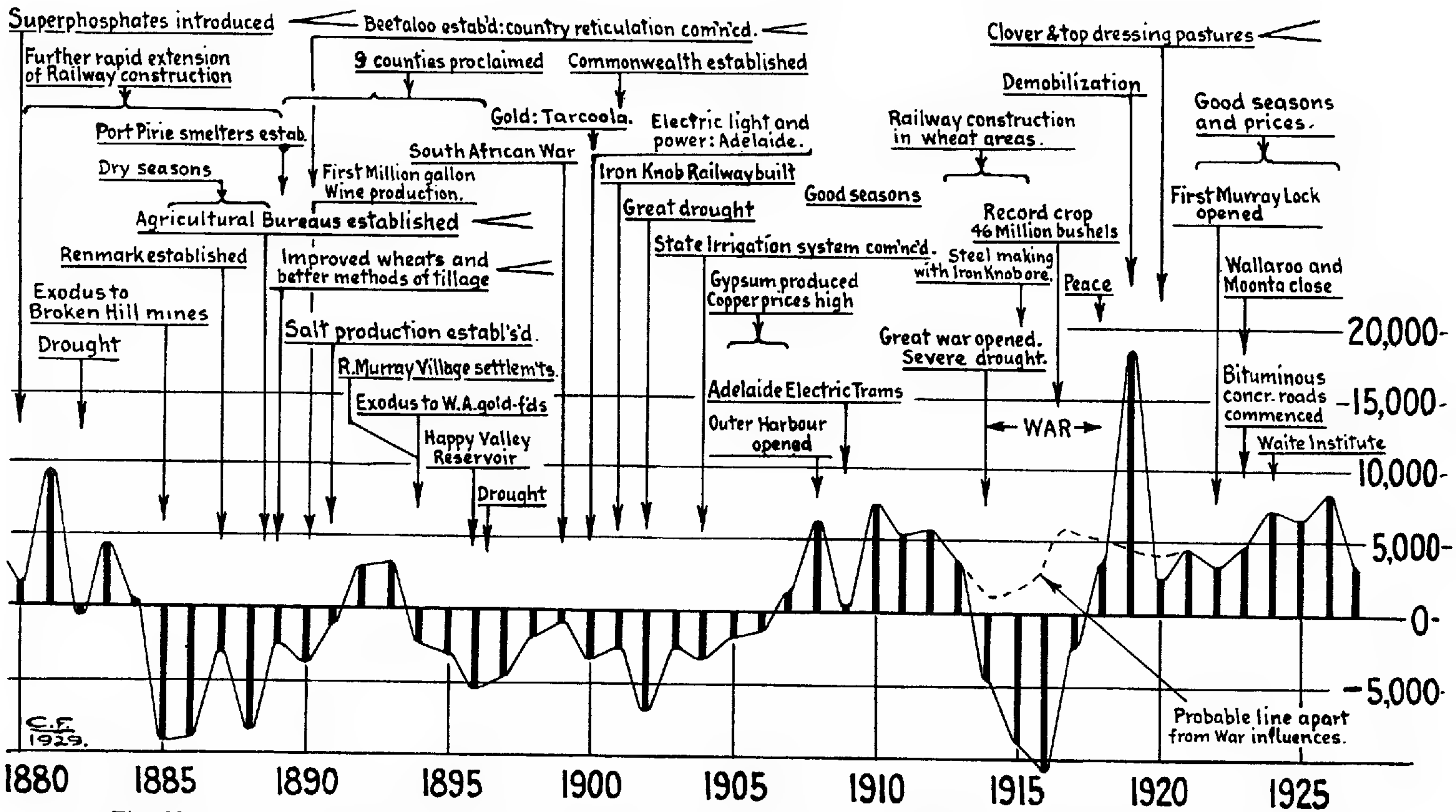

Fig. 22b. The "Prosperity Graph" of South Australia,—really a curve showing the yearly excess of Immigration over Emigration, or the r everse. With annotations.

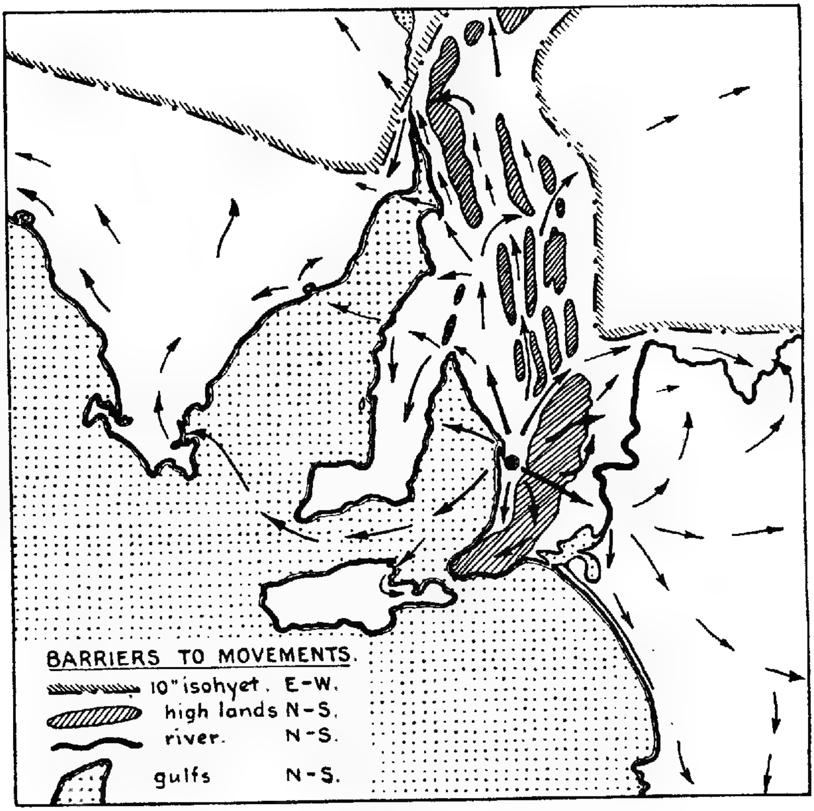

Fig. 23.

This figure has been drawn to show the routes followed in the progressive movements of population from Adelaide outward: First into the remainder of the Adelaide-Mount Lofty region, then to the South-East, later to the North, to Yorke Peninsula, and the West Coast, to the Murray Mallee, and finally to the Murray Valley itself. The arrows are intended to show the general directions in which the outward (dispersive) flow of population has taken place, and the relation of such corridors of communication to the topographic features. The physiographic barriers to population movement may be summarised as follow:—(i.) a barrier to northward movement, constituted by the zone of 10-inch annual rainfall; (ii.) barriers to East-West movement: Spencer Gulf, Gulf St. Vincent, the Mount Lofty Ranges, the Murray River (of these, the two gulfs and the river have been utilised as channels of communication); (iii.) Both in the West and in the East (Central Eyre Peninsula and east of the Coorong, respectively) the wide streamless mallee plains have acted, to some extent, as barriers to population movement. As indicated by the sketch map, population has radiated continuously from Adelaide, with subordinate centres at Tailem Bend and Port Lincoln. The only "open road" from the capital is that across the plains to the North; to the nearer West the way is by sea or air across the Gulfs; to the East the high barrier of the Mount Lofty Ranges, though surmounted, presents a never-ending hindrance to cheap transport and communication in that direction. The sketch map indicates the impressive way in which physiographic features have affected the progress of settlement of the State. The routes here defined should be studied in conjunction with the spot-maps in preceding sections that deal with the detailed movements of dispersion and concentration of population.

While acknowledging, as we have done, the fact that complex financial and legislative factors have played an important part in this latest cycle of prosperity, we cannot be far wrong in interpreting it mainly as the outcome, during a series of good seasons, of cumulative advances in the adjustment of agricultural practice to the natural environment provided within the borders of our State. In this adjustment we should include not only agricultural extension and practice, but also improvements in stock-raising, fruit-growing, vine-growing, forestry, mining, manufacturing, water supplies, transport, communications, and marketing.

(d) *Conclusion.*—While this paper is purely a geographical study of the growth and movement of the population of South Australia, as determined by the environmental conditions, and varied by man's re-action to those conditions, it is inevitable that the intensive study of the various tendencies that have operated during the life of the State should suggest "direction-marks" regarding the future.

Without departing from the strict line of unbiassed scientific research, it is thus permissible to set down some suggestions regarding the future, it being understood that such suggestions (which are not new) are re-stated purely from the geographical point of view, with the added emphasis provided by the evidence that has been collected and presented in this paper. They are as follow:—

1. The foundation of a stable and growing population is a steady birth rate; the ebb and flow of immigration is, to a great extent, automatically governed by those environmental factors that determine general prosperous or adverse conditions.

2. Within the southern division of the State, *i.e.*, "The Counties," periods of depression will recur, as dry seasons most certainly will; but the tendency is for these to press less and less heavily, in proportion to the continued adoption of the sound methods and thrifty habits that have developed under our special geographical conditions.

3. In the endeavour to co-operate with the geographical environment of the various regions of the State, and to combat the adverse influences, there is required further concentration towards: (a) plant, animal, topographical, and soil research; (b) the preparation of maps of all forms of State resources; and (c) the wide-spread dissemination, by education, of scientific, engineering, and agricultural knowledge and skill.

4. Beyond "The Counties," in the purely pastoral regions north of the 10-inch line of rainfall, where droughts are more frequent, the decimating effects of dry seasons on the flocks and herds may be somewhat ameliorated by a rigid avoidance of over-stocking and over-feeding. Apart from minerals, the chief wealth of this great area is its mantle of native vegetation, the existence of which is at present in peril.

5. Agricultural settlement has reached its northern limits, and these limits are, on the whole, well within the boundaries of the counties; future efforts should be devoted to the occupation of areas yet unoccupied within the counties, and to the more intense utilization of well-watered land that is already under occupation.

AUSTRALIAN ACANTHOCEPHALA, No. 1.

CENSUS OF RECORDED HOSTS AND PARASITES.

By Professor T. Harvey Johnston and Effie W. Deland, B.Sc.,
University of Adelaide.

[Read August 8, 1929.]

Australian Acanthocephala have received very little attention. Dr. Sweet (1909, 498), in her census of the entozoa recorded from Australia, included only four, together with one from the Bismarck Archipelago. Of these four, two were merely mention of *Echinorhynchus* sp. from a porpoise and from a whip snake, both recorded by Krefft (1871); one relates to the presence of the common acanthocephalan from the pig in New South Wales; and the fourth, a species described by Linstow (1898) from material collected by Semon from a bandicoot in the Burnett River district, Queensland. The senior author added other records, using the wide generic term, *Echinorhynchus* sp. (1910-1912), besides describing a few new forms. More recently Southwell and Macfie (1925) described several new species. *Echinorhynchus pomatostomi* Johnston and Cleland (1911), frequently referred to in this census, is a widely distributed larval form occurring in many species of Australian birds.

The forms mentioned as occurring in Australian birds and reptiles to date were included in Johnston's census of recorded entozoa of those groups (1910, 1911, 1912); while those known to occur in Queensland were included in the census of endoparasites recorded from that State (Johnston 1916). Cleland (1922) listed those found in Australian birds and mentioned additional findings, and in 1916 made casual reference to Johnston's records of Acanthocephala from Australian rats.

A considerable mass of material is now on hand, representing collections made by Professor J. B. Cleland and the senior author, and it is proposed to take up the study more seriously, the present paper forming the first of a series which, it is hoped, will be continued as opportunity offers. In this census, the previous records, with few exceptions, are listed without comment, and a number of new ones are added. Synonymy of the host or parasite is introduced only where the recorder has referred to either under such name or names. The bird hosts are named and arranged in accordance with the "Official Check-list of Birds of Australia," Edit. 2, 1926.

MAMMALIA.

MARSUPIALIA.

Isoodon obesulus Shaw (syn. *Perameles obesulus*).

Gigantorhynchus semoni Linstow 1898, 471. Burnett R., Q'land.; Porta 1908, 276; 1909, 257. Originally described under *Echinorhynchus*, subgenus *Gigantorhynchus*. Travassos (1917, 25) transferred it to *Prosthenorchis* (sensu lato). Johnston recorded its presence in N.S. Wales (1909 e, 521).

Perameles nasuta Geoffr.

Gigantorhynchus semoni Linst. Johnston 1910 c, XVII, as *Gigantorhynchus* sp.; 1911 a, 50. N.S. Wales.

PHASCOGALE PENICILLATA Shaw.

Gigantorhynchus sp. Johnston 1910 c, XVII.; 1911 a, 50. The host, "a brush-tailed rat," may possibly be *Bettongia penicillata* Gray.

RODENTIA.

MUS MUSCULUS L.

Moniliformis moniliformis Br. The record by Johnston (1909 a, 583, Sydney) is an error (Johnston 1918 a, 69).

RATTUS NORVEGICUS Erxl. *(Mus* or *Epimys decumanus).*

Moniliformis moniliformis Br. syn. *Gigantorhynchus moniliformis; Hormorhynchus moniliformis.* Johnston 1909 a, 583; 1909 b, 218; 1909 d, 81, N.S.W.; 1912 b, 83, Brisbane; 1913, 93, N. Q'land; 1918 a, 69, Sydney. Southwell and Macfie 1925, 171, N. Q'land; Fielding 1927, 124, N. Q'land. This parasite occurs in the grey rat in Adelaide.

RATTUS RATTUS L. and its variety ALEXANDRINUS. *(Mus* or *Epimys rattus* and *alexandrinus).*

Moniliformis moniliformis Br. Johnston 1909 a, 583; 1909 b, 218, 590; 1909 d, 81, N.S.W.; 1912 b, 83, Brisbane; 1918 a, 69, Sydney. Southwell and Macfie 1925, 171, N. Q'land; Fielding 1927, 124, N. Q'land. Occurs also in *R. rattus* in Adelaide.

RATS (unspecified).

Moniliformis moniliformis Br. Nicoll 1914, N. Q'land.

UNGULATA.

SUS SCROFA L. dom.

Macracanthorhynchus hirundinaceus Pall. *(Gigantorhynchus hirundinaceus; G. gigas).* Perrie (Agr. Gaz., N.S.W., 3, 1892, 822) N.S.W.; Johnston 1909 a, 583; 1909 d, 79, N.S.W.; 1918 b, 216 (S.E. Q'land). This parasite occurs at times in Victorian pigs slaughtered in Adelaide, but has not yet been detected in pigs bred in South Australia.

CETACEA.

DELPHINUS FORSTERI Gray.

Probably a synonym of *D. delphis L. Echinorhynchus* sp. Krefft 1871, 212 (Australian seas).

DELPHINUS DELPHIS L.

Corynosoma sp., resembling *C. strumosum* Rud., has been collected from this porpoise in Gulf St. Vincent, S. Aust.

WHALE—cast up on Bondi Beach, Sydney, N.S.W.

Bolbosoma porrigens Rud. nec Kaiser. Not previously recorded from Australian seas. The longest specimen measured 197 mm., which is much greater than the dimension usually met with. *B. porrigens* of Kaiser nec Rudolphi is, according to Luhe (1905), a synonym of *B. turbinella* Dies. which has been recorded from a whale from New Zealand. Through the courtesy of Dr. C. Anderson, Director of the Australian Museum, Sydney, and Mr. E. Troughton, the old registers of that institution were searched for a clue as to the probable identification of the whale. The only specimens likely to be concerned were those identified as *Kogia breviceps (grayi)* and *Megaptera longimana,* belonging to the Physeteridae and Balaenidae respectively, both obtained in the vicinity of Bondi,

N.S.W. Since the parasite seems to be especially associated with species of the latter family, the host was probably *Megaptera nodosa* Bonnaterre (syn. *M. longimana* Rud.).

AVES.

GALLIFORMES.

ALECTURA LATHAMI Gray. *(Catheturus lathami).*

Echinorhynchus (Gigantorhynchus) sp. Johnston 1912 a, 106; 1912 b, 72; 1916, 45 S. Q'land. Probably a species of *Mediorhynchus* or *Empodius,* if the latter be generically distinct. Van Cleave (1924) unites them but Travassos (1924, 1926), as well as Southwell and Macfie (1925), consider them distinct.

TURNICIFORMES.

PEDIONOMUS TORQUATUS Gould.

Echinorhynchus pomatostomi Jnstn. and Clel.—a larval form identified from material collected at Ooldea, S.A.

CHARADRIIFORMES.

NUMENIUS CYANOPUS Vieill.

Arythmorhynchus sp. (syn. *Echinorhynchus* sp.) Johnston 1912 a, 107, Central Q'land; 1914 a, 110, N. Q'land.

ACCIPITRIFORMES.

ASTUR NOVAEHOLLANDIAE Gmelin (syns. *Astur clarus* Lath.; *A. cinereus* Vieill).

Centrorhynchus asturinus Johnston, originally described as *Gigantorhynchus asturinus* Johnston 1912 a, 108; 1913, 93; but later transferred to *Centrorhynchus* (1918 b, 215). Southwell and Macfie 1925, 164, N. Q'land. Travassos (1917, 28) included the species in *Gigantorhynchus* (sensu lato), and subsequently (1926, 44) under *Centrorhynchus.*

ASTUR FASCIATUS Vig. and Horsf. (syn. *A. approximans).*

Centrorhynchus asturinus Johnston, syn. *Echinorhynchus* sp. Johnston 1910, 100, N.S.W. Occurs in this species of hawk in Adelaide district, S. Austr. (Collected by Prof. Cleland.)

ACCIPITER CIRROCEPHALUS Vieill.

Centrorhynchus asturinus Johnston. Southwell and Macfie 1925, 163. Townsville. This parasite occurs in the same host species in N.S.W.

Centrorhynchus buteonis Goeze. Marval 1905, 24, no locality given.

BAZA SUBCRISTATA Gould.

Centrorhynchus asturinus Johnston 1918 b, 215. Richmond River, N.S.W.

Echinorhynchus bazae Southwell and Macfie 1925, 177, N. Q'land. Travassos (1926, 59) believes the species to be a *Prosthorhynchus.*

FALCO BERIGORA Vig. and Horsf., syn. *Hieracidea berigora;*
H. orientalis Sharpe.

Centrorhynchus asturinus Johnston, Southwell and Macfie 1925, 164, N Q'land. It is now recorded as occurring in the brown hawk in N.S.W.

STRIGIFORMES.

NINOX BOOBOOK Lath.

Centrorhynchus sp. Johnston 1918 b, 216; syn. *Echinorhynchus* sp. Johnston 1912, 109. Burnett River, Q'land.

CORACIIFORMES.

EURYSTOMUS ORIENTALIS L. (syn. *E. pacificus* Lath.).

Echinorhynchus sp. Johnston 1912 a, 109, S. Q'land.

HALCYON SANCTUS Vig. and Horsf.

Echinorhynchus sp. Johnston 1910, 105, N.S.W. Probably identical with *E. horridus* Linstow (1897) from the sacred kingfisher from New Britain. Porta (1913) recorded it from *H. sanctus* from New Caledonia and Loyalty Islands, transferring it to *Chentrosoma*. Linstow's original material was re-described by Marval (1905, 284-6). Travassos (1926, 58) transferred the species to *Prosthorhynchus*.

CUCULIFORMES.

CENTROPUS PHASIANINUS Lath.

Echinorhynchus bulbocaudatus Southwell and Macfie 1925, 178, N. Q'land. Travassos (1926, 59) believes the species to belong to *Prosthorhynchus*.

MENURIFORMES.

MENURA NOVAEHOLLANDIAE Lath. (syn. *M. superba* Davies).

Echinorhynchus menurae Johnston 1912 b, 83, N.S.W. Travassos (1926, 58) placed the species under *Prosthorhynchus*.

PASSERIFORMES.

SEISURA INQUIETA Lath.

Acanthocephala found by Cleland 1922, 108. Canowindra, N.S.W.

PACHYCEPHALA INORNATA Gould (syn. *P. gilberti* Gould).

Echinorhynchus pomatostomi Jnstn. and Clel. 1911, 115, S. Austr.

GRALLINA CYANOLEUCA Lath. (syn. *G. picata* Lath.).

Echinorhynchus sp. Johnston 1912 a, 110; 1914, 110, N. Q'land.

PSOPHODES OLIVACEUS Lath. (syn. *P. crepitans* Lath.).

Echinorhynchus sp. Johnston 1910, 107, N.S.W. Acanthocephala found by Cleland (1922, 108), Bunya Mountains, S. Q'land.

CINCLOSOMA RUFIVENTRIS Gould.

Echinorhynchus pomatostomi Jnstn. and Clel., Port Lincoln, S. Austr. A new record.

CINCLOSOMA CASTANEUM Gould.

Echinorhynchus pomatostomi Jnstn. and Clel., Murray Flats, S. Austr. A new record.

CINCLOSOMA CINNAMONEUM Gould.

Echinorhynchus pomatostomi Jnstn. and Clel., larvae in subcutaneous tissues. Cleland 1922, 108, S. Austr.

POMATOSTOMUS TEMPORALIS Vig. and Horsf. (syn. *P. frivolus* Lath.).

Echinorhynchus pomatostomi Jnstn. and Clel., 1911, 112, N.S.W. Cleland 1922, 108, Canowindra, N.S.W.

Pomatostomus rubeculus Gould.

Echinorhynchus pomatostomi Jnstn. and Clel., 1911, 111; syn. *Echinorhynchus* sp. Johnston 1910, N.-W. Austr.

Pomatostomus superciliosus Vig. and Horsf.

Echinorhynchus pomatostomi Jnstn. and Clel. 1911, 112; syn. *Echinorhynchus* sp. Johnston 1910, 107, S. Austr. Cleland 1922, 108, Hallett's Cove, S. Austr.; Baradine, N.S.W.

Pomatostomus ruficeps Hartlaub.

Echinorhynchus pomatostomi Jnstn. and Clel. Identified from material collected in the Gawler Ranges and also from the Murray River district, S. Austr. The latter occurrence is referred to by J. Sutton, S. Austr. Ornithol., 10, 1929, 33.

Oreocichla lunulata Lath.

Echinorhynchus sp. Johnston 1910, 108, N.S.W. (An adult form.)

Echinorhynchus pomatostomi Jnstn. and Clel. (larval). Cleland 1922, 108, Kuitpo, S. Austr. Acanthocephala were recorded by the latter author (1922) from Bunya Mountains, Q'land.

Aphelocephala leucopsis Gould.

Echinorhynchus pomatostomi Jnstn. and Clel. 1911, 112 (syn. *Echinorhynchus* sp. Jnstn 1910, 109), S. Austr. Cleland 1922, 108, Hallett's Cove, S. Austr.

Sericornis maculatus Gould.

Echinorhynchus sp. (subcutaneous, probably *E. pomatostomi*), Port Lincoln, S. Austr., collected by Professor Cleland. A new record.

Pyrrholaemus brunneus Gould.

Echinorhynchus pomatostomi, Jnstn. and Clel. Identified from material collected near Farina, S. Austr.

Hylacola pyrrhopygia Vig. and Horsf.

Echinorhynchus pomatostomi Jnstn. and Clel. 1911, 112, S. Austr.

Megalurus galactotes Temm.

Echinorhynchus cylindraceus Goeze. Marval 1905, 250. No locality given. The host is widely distributed in the more northerly portions of Australia. The parasite has a wide distribution outside of Australia, and has also been recorded from *Merulus* from the Loyalty Islands by Porta in 1913.

Travassos (1926, 41, 43, 58) has quoted Marval's *E. cylindraceus* as including two different species of *Centrorhynchus*, *C. cylindraceus* Goeze and *C. fasciatus* Westr., as well as *Prosthorhynchus dimorphocephalus* Westr. Marval also included *P. rectus* Linton, which Travassos regards as a valid species. In view of the confusion existing, a re-examination of Australasian material, attributed to Goeze's species, is desirable.

Climacteris picumnus Temm. Syn. *C. scandens* Gould nec Temm.

Echinorhynchus pomatostomi Jnstn. and Clel. Mr. F. Parsons informs us that this larval parasite is very commonly found subcutaneously in this species of tree creeper in South Australia. Cleland 1922, 108, Morgan, S. Austr.

CLIMACTERIS LEUCOPHAEA Lath. Syn. *C. scandens* Temm. nec Gould.

Echinorhynchus pomatostomi Jnstn. and Clel. occurs occasionally in this species in South Australia (F. Parsons).

CLIMACTERIS WELLSI Grant.

Echinorhynchus pomatostomi Jnstn. and Clel, 1911, 111; syn. *Echinorhynchus* sp. Johnston 1910, 109, N.-W. Austr.

MELIORNIS NOVAEHOLLANDIAE Lath.

Echinorhynchus sp. Johnston 1910, 111, N.S.W.

CORCORAX MELANORHAMPHUS Vieill.

Echinorhynchus reported by Cleland 1922, 108, from Gunnedah and Belaringar, N.S.W.

REPTILIA.

LACERTILIA.

LYGOSOMA (HINULIA) QUOYI D. & B.

Echinorhynchus sp. Johnston 1909 c, XXIX., Hawkesbury R., N.S.W.

LYGOSOMA (HINULIA) TAENIOLATUM White.

Echinorhynchus sp. Johnston 1911 b, 243, Hawkesbury R., N.S.W.

DEMANSIA TEXTILIS D. & B. (syn. *Diemenia textilis).*

Echinorhynchus sp., encysted larvae below peritoneum, adults in intestine. Johnston 1910 c, XI.; 1910 b, 659; 1911 b, 237, Sydney, N.S.W.; encysted larvae —Johnston 1916, 59, Brisbane. Occurs also at Mount Lofty, S. Austr.

DEMANSIA PSAMMOPHIS Schl.

Echinorhynchus sp. Larvae below peritoneum. Brisbane, Q'land.

DEMANSIA PSAMMOPHIS, var. RETICULATA Krefft. (Syn. *Diemenia reticulata.)*

Echinorhynchus sp. Krefft 1871, 214, N.-W. Austr. Larvae in subperitoneal tissue, Johnston 1910 b, 659; 1911 b, 237. N.-W. Austr.

PSEUDECHIS PORPHYRIACUS Shaw.

Echinorhynchus rotundocapitatus Johnston 1912 b, 83, N.S.W. and Victoria; 1918 b, 216, S. Q'land; syn. *Echinorhynchus* sp. Johnston 1909 b. 590; 1911 b, 238, N.S.W. Occurs also in South Australia.

DIPSADOMORPHUS FUSCUS Gray.

Echinorhynchus sp., encysted larvae, Johnston 1916, 59, Brisbane.

AMPHIBIA.

ANURA.

HYLA AUREA Lesson.

Echinorhynchus hylae Johnston 1914, 83; syn. *Echinorhynchus* sp. Johnston 1912, 84, Sydney. A larval form from cysts below peritoneum.

HYLA COERULEA White.

Echinorhynchus hylae Johnston 1914, 83, from cyst below peritoneum. Brisbane.

PISCES.

The arrangement followed is taken from MacCulloch's "Check list of the Fishes of N.S. Wales," 1922.

PERCOMORPHI.

TRACHURUS DECLIVIS Jenyns.

Echinorhynchus clavulus Duj. nec Hamann. Southwell and Macfie 1925, 179. Australia. As the specimen was collected by Dr. Maplestone on the same date as that on which he took Acanthocephala from another fish at Townsville, N. Q'land, the latter must have been the locality for the species thus identified.

POMADASYS HASTA Gunther.

Echinorhynchus truttae Schrank, was recorded from a "grunter" by Southwell and Macfie (1925, 180) from Townsville, N. Q'land. Since *P. hasta*, the javelin fish, is also called "grunter" locally, and was so indicated by Nicoll who investigated its trematode fauna, it may safely be assumed that this is the species referred to. The identification of this typical parasite of trout in a quite different type of fish which is tropical and subtropical in its distribution, seems to us very doubtful.

SPARUS AUSTRALIS Gunther.

Echinorhynchus sp. Nicoll 1914, N. Q'land. We have collected specimens from this "black bream" in the Brisbane River, S. Q'land.

SPARUS BERDA Forsk.

Echinorhynchus clavula Duj. nec Hamann. Southwell and Macfie 1925, 179. Townsville, N. Q'land.

Echinorhynchus truttae Schrank. Southwell and Macfie 1925, 180. No locality given, but apparently collected at Townsville, also.

We question the correctness of both of these identifications, and suggest the possibility of the host label having become misplaced (see under *Pomadasys*, also).

GIRELLA TRICUSPIDATA Q. & G. (Syn. *G. simplex* Richardson.)
Echinorhynchus sp. Johnston 1909 c, XXIX, Bondi, N.S.W.

THYRSITES ATUN Euphr.

Echinorhynchus sp. Johnston 1909 b, 710, Clarence River, N.S.W.

SCLEROPAREI.

CHELIDONICHTHYS KUMU Less and Garn.
Echinorhynchus sp. Johnston 1910 b, 660, Sydney, N.S.W.

PLATYCEPHALUS FUSCUS Cuv. and Val.

Echinorhynchus sp. Johnston 1910 b, 660, Sydney, N.S.W.

Serrasentis socialis Leidy. Southwell and Macfie (1925, 160) record the presence of larvae belonging to this species encysted in the body cavity of this flathead at Townsville, N. Q'land. The parasite is more widely known as *S. sagittifer* Linton. (See Van Cleave 1924, 326-8.)

UNKNOWN FISH, but probably the Tailor, POMATOMUS SALTATRIX L.

Serrasentis socialis Leidy. Adult specimens obtained by the senior author from a fish caught at Sydney, N.S.W.

"HADDOCK."

Echinorhynchus gadi Zoega. Southwell and Macfie 1925, 179, Townsville, N. Q'land. The haddock, *Gadus aeglefinus,* does not occur in Australia. Neither MacCulloch nor Waite, in their catalogues of the fishes of Queensland, New South Wales and South Australia, mentions the presence of any species of *Gadus* in Australian waters, though the family Gadidae is represented in the more southerly portions of the coast by *Lotella* and *Physiculus.* Gunther ("Study of Fishes," 1880) states that the genus *Gadus* is found in the arctic and temperate zones of the northern hemisphere. In view of these facts, it seems likely that the locality label must have become misplaced and that the record should be omitted from the Australian list.

HOST UNKNOWN.

Neoechinorhynchus magnus Southwell and Macfie 1925, 149, Townsville, N. Q'land. A short, unfigured account based on one immature female specimen. The genus occurs in fish and chelonians.

A number of errors regarding localities have appeared in Travassos' paper (1926). Those relating to Australasian records are as follows:—*Centrorhynchus zosteropis* (Porta) recorded as from Turkestan should be from New Caledonia and Loyalty Islands; *C. asturinus* Jnstn. from New Caledonia should be from Australia; *C. spinosus* (Kaiser) from Australia should be from Florida; *C. giganteus* Trav. from Australia should be from Brazil; *Centrorhynchus* sp. Jnstn. from *Ninox boobook,* mentioned as from Brazil, should be from Australia.

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AUSTRALIAN ACANTHOCEPHALA, No. 2.

By Prof. T. Harvey Johnston and Effie W. Deland, B.Sc.,
University of Adelaide.

[Read August 8, 1929.]

Sphaerechinorhynchus rotundocapitatus (Jnstn.), n. gen.
Figs. 1 to 34.

This parasite occurs fairly commonly in the rectum and lower part of the intestine of the black snake, *Pseudechis porphyriacus* Shaw, in New South Wales, Victoria and Southern Queensland, and has been recorded recently from South Australia (Johnston and Deland 1929). It was originally described (Johnston 1912, 83) under *Echinorhynchus*, a genus which has since been considerably subdivided.

The body is firm and roughly cylindrical, white in life, but creamy, or even pinkish, in preserved material. The cuticle is smooth in extended, and transversely wrinkled in contracted, specimens.

The females are larger and, when mature, range from 30 to 37 mm. in length. One young individual was only 18 mm. The body is wide (4 to 5 mm. in diameter) for the anterior two-thirds, and tapers to 1·5 to 2·0 mm. The posterior extremity is bifid, the genital aperture lying slightly below the apex of the cavity between the two lobes (figs. 30, 31).

The males range from 18 to 23 mm. in length and are much less tapering than the females. The width anteriorly is about 3 mm., and posteriorly about 2 mm. The form of the posterior end varies with the degree of extension. In one specimen the copulatory bursa was everted, appearing as a delicate, white, bell-shaped structure of the form shown in figs. 28 and 29.

The above measurements were taken from material preserved in formalin and containing a large number of individuals. In specimens preserved in spirit, and obviously much contracted, the lengths were—female, 15 mm.; males, 12 and 14·5 mm.

The proboscis is nearly spherical, measuring from 0·7 to 0·85 mm. across, and bears 18 longitudinal rows of hooks with alternately 6 and 7 in a row, making 117 in all (fig. 1). Each hook consists of a strong backwardly projecting outer spine and a large basal portion embedded in the musculature of the proboscis. They are largest at the apex, becoming very much smaller at the base. Three typical hooks, the apical three of their row, are shown in fig. 3. There is a short neck-like region followed by a somewhat wider collar connecting it with the body (fig. 2). The body wall is composed, as usual, of a cuticle, a thick subcuticula, and two layers of muscle fibres, an external circular and an internal longitudinal (figs. 9, 12). The subcuticula shows all the areas generally present. A region of radial striations lies immediately below the cuticle, which it slightly exceeds in thickness. Beneath this is a distinct layer of mingled circular, tangential and radial fibrils, divided into six to eight strata by the circular fibrils. This arrangement is less pronounced than that indicated by Saefftigen (1885), for *Echinorhynchus proteus* Westr., which is now usually known as *Pomphorhynchus laevis* Muller, and recently by Harada for *Rhadinorhynchus katsuwonis*. Below this layer is one of radially-arranged fibrils in which travel the channels of the lacunar system. The subcuticula is bounded by a thin but definite limiting membrane. The nuclei of the subcuticula are typical of those of the whole body (figs. 7, 10). They are not situated in the fibrous portion of the subcuticula nor in the walls of the lacunae, as figured by Hamann for *Ech. echinodiscus* Dies.

(= *Gigantorhynchus echinodiscus*), but are suspended in the middle of the lacunae by strands of tissue. Saefftigen (pl. 3, figs. 1, 3) indicates them in this position but without any supporting fibrils. The nuclei, which measure 0·02 to 0·03 mm. in their longer axis, are irregular in outline and contain numerous very obvious nucleoli, of which there may be as many as a dozen, ranging in size from the smallest which are mere dots under oil immersion, to a maximum of 0·0075 mm. (fig. 10). The variations in size and shape of the nuclei, and in number of the nucleoli, are greater in the subcuticula than elsewhere in the body.

The lacunar system consists of two definite longitudinal canals in addition to very numerous smaller channels of rather irregular outline, which form a close

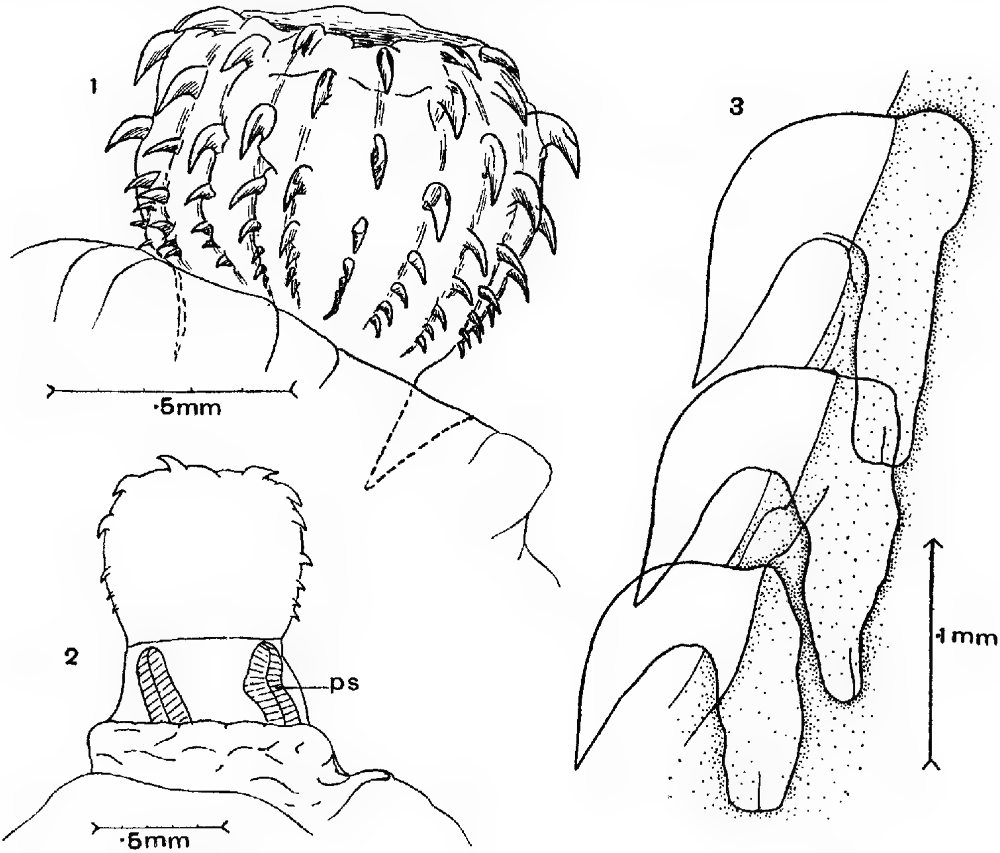

Fig. 1.—Proboscis.
Fig. 2.—Outline of anterior end indicating insertion of proboscis sheath.
Fig. 3. Three most anterior hooks of one longitudinal row.

network throughout the subcuticula (fig. 8). The canals in the lemnisci are single and centrally situated (fig. 15).

Beneath the subcuticula lie layers of circular and longitudinal muscle fibres. Within the spaces surrounding the bases of these a certain amount of a granular coagulum, which stained deeply with haematoxylin, was sometimes found. A similar substance occurred in spaces in the proboscis (fig. 18) and male genital organs, but such material was not seen in the lacunar system.

The proboscis sheath is a double-walled muscular sac inserted at the base of the proboscis (fig. 2). Its length varies from 2·5 to 2·7 mm., and its maximum width from 1·05 to 0·75 mm. The central region is occupied by four large, branching retractor muscle cells, which are attached to the muscular wall of the

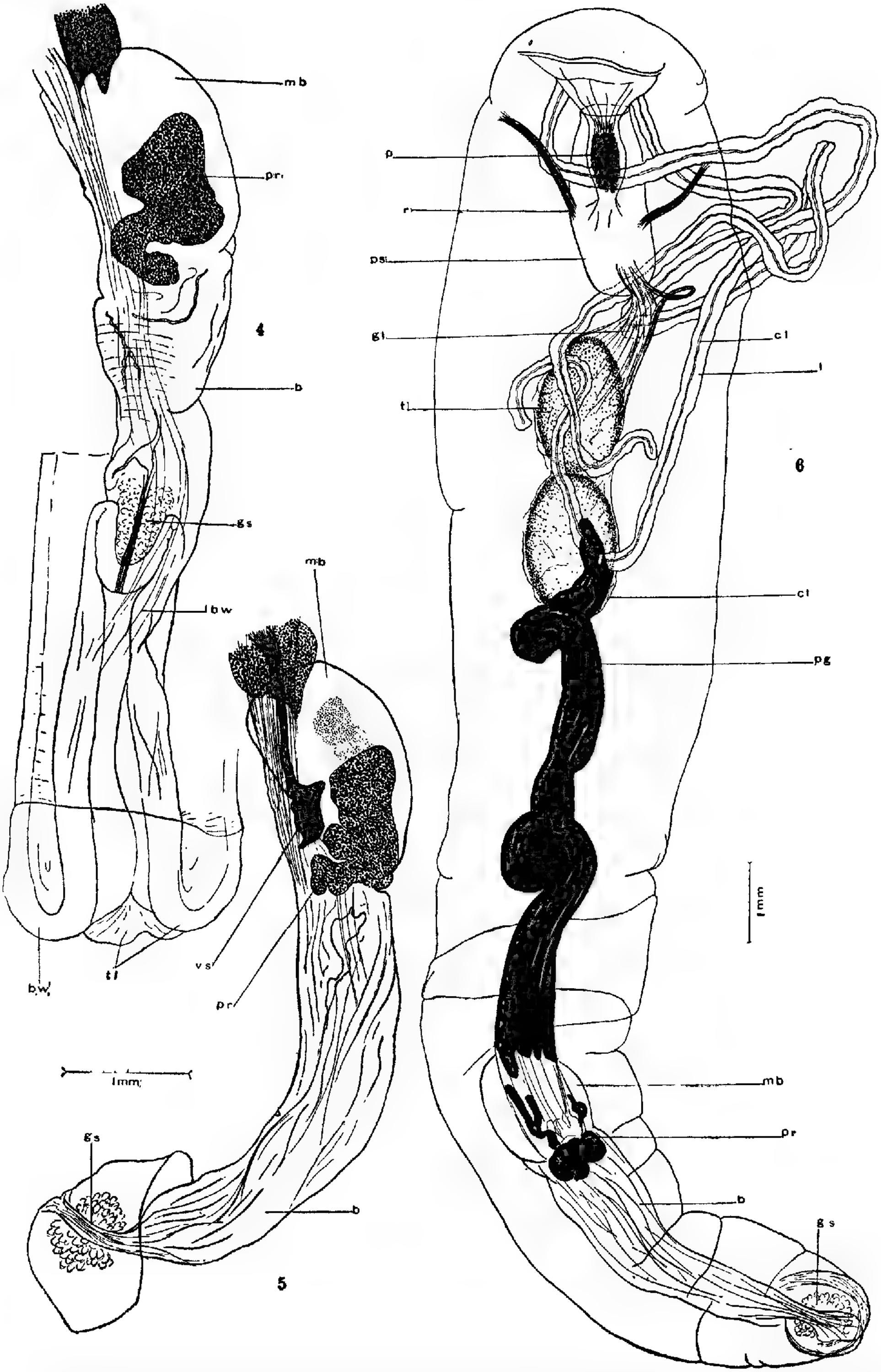

Fig. 4.—Portion of posterior end of male, showing end of body deeply invaginated.
Fig. 5.—Ditto, showing genital sphincter in terminal position. Drawn to same scale as fig. 4.
Fig. 6.—Entire male, showing anatomy.

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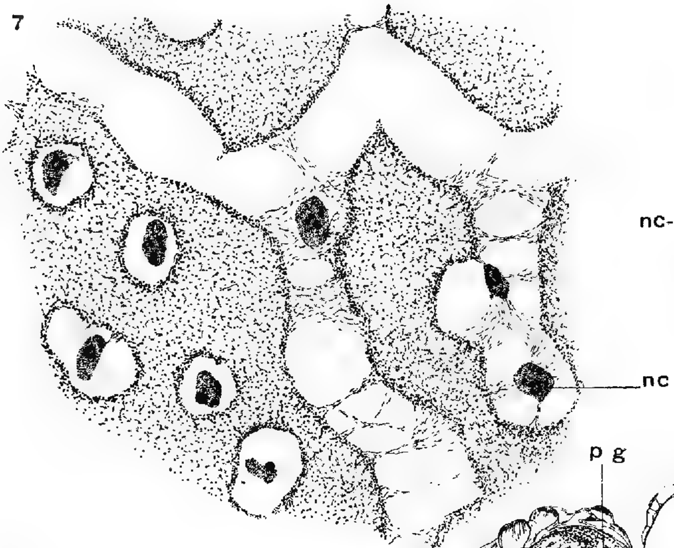

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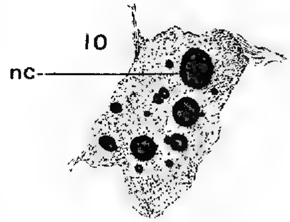

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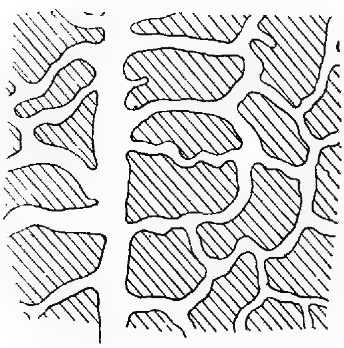

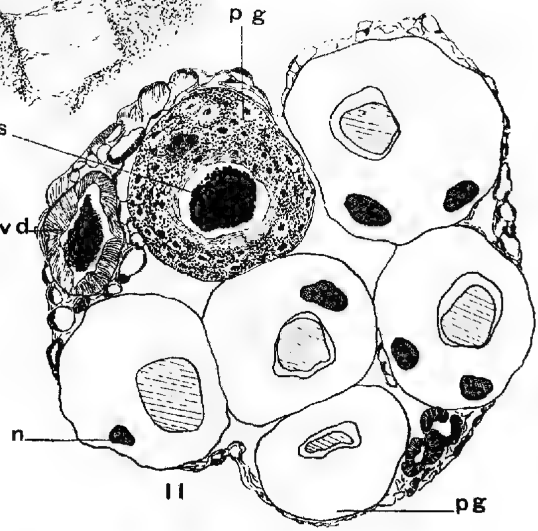

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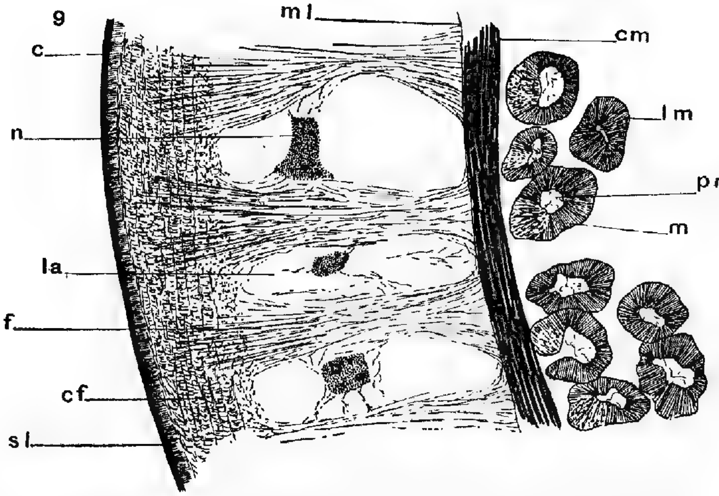

Fig. 7.—Lacunar system of body wall (from tangential section).
Fig. 8.—Lacunar system of part of body viewed as a transparent object.
Fig. 9.—Portion of T.S. body wall.
Fig. 10.—Nucleus from subcuticula.
Fig. 11.—T.S. of prostate glands and vas deferens.

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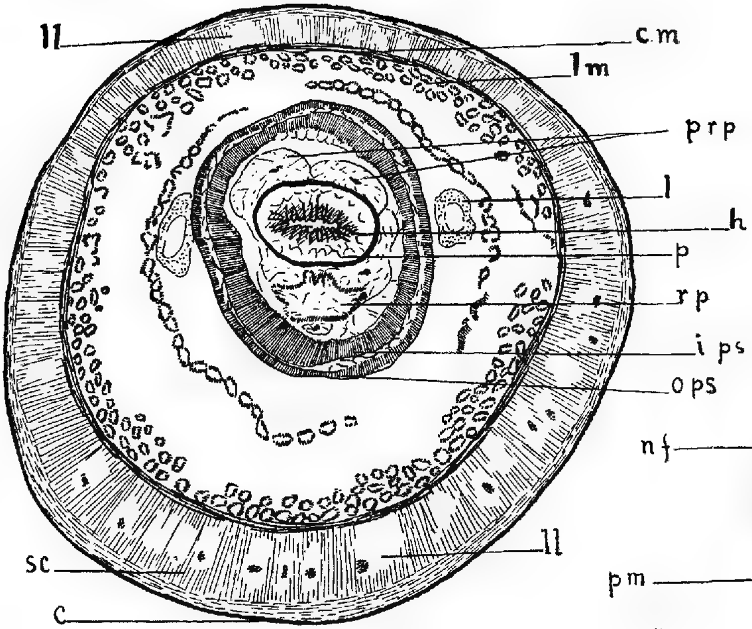

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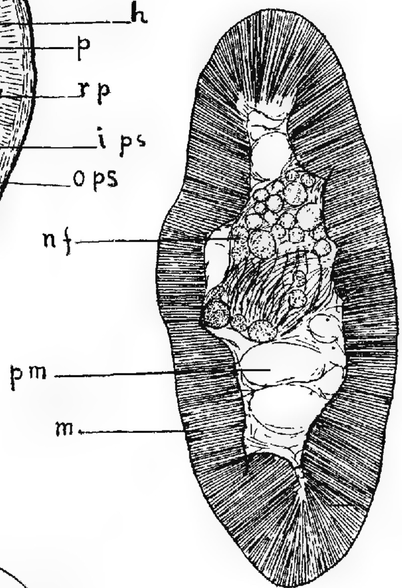

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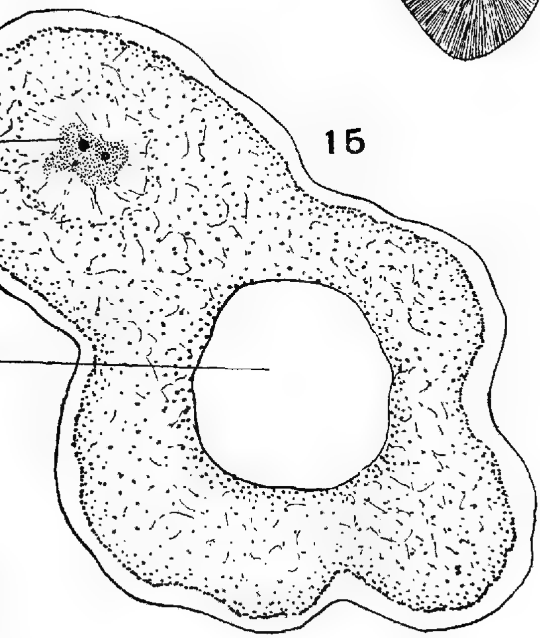

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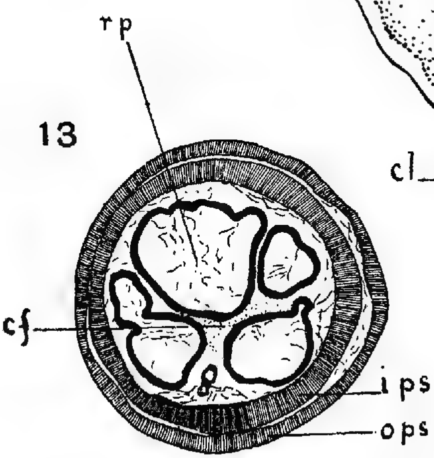

Fig. 12.—T.S. body at level of introverted proboscis.
Fig. 13.—T.S. proboscis posterior to fig. 12.
Fig. 14.—T.S. retinaculum, showing enclosed nerve fibres.
Fig. 15.—T.S. lemniscus.

proboscis in front and the inner proboscis sheath at its base. The protoplasmic portion of these cells lies anteriorly, surrounding the retracted proboscis (fig. 12). These cells are shown in transverse section in fig. 13, and two of them in longitudinal section in fig. 18.

The proboscis ganglion is situated eccentrically in the space between the four large retractor muscle cells (fig. 18), somewhat in advance of the mid-length of the proboscis sheath. It consists of a comparatively small number of cells (fig. 16), and does not show as marked a differentiation into a peripheral layer of nerve cells and a central mass of fibres or supporting tissue, as that described

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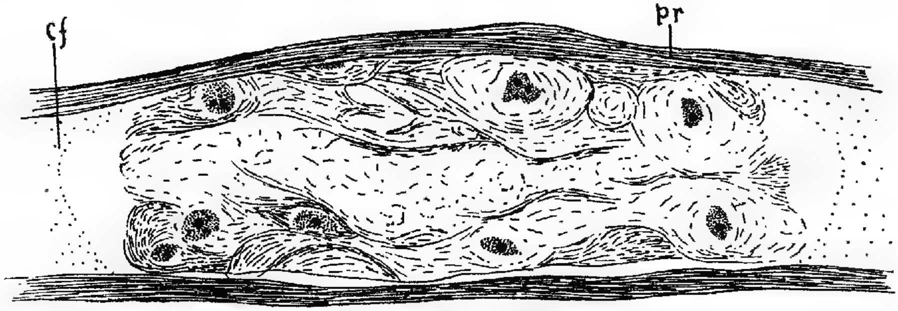

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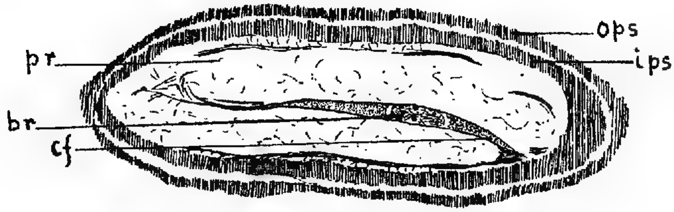

Fig. 16.—L.S. ganglion.
Fig. 17.—Cell (? supporting) from ganglion.
Fig. 18.—L.S. proboscis, showing situation of ganglion; one-tenth magnification of figs. 16, 17.

by Hamann and Saefftigen. It is possible that some of the nuclei observed in the ganglion belong to a syncytial supporting tissue similar to that of the subcuticula, as in two or three cases it was not possible to observe any cell boundary between neighbouring nuclei (fig. 17).

The retinacula arise from the sides of the proboscis sheath, about a millimetre from its posterior end, and pass obliquely forwards to the body wall. In transverse section, each is seen to be composed of a muscular sheath consisting of one long muscle cell which encloses a bundle of nerve fibres (fig. 14).

The two lemnisci which arise at the junction of the proboscis sheath and the general body wall are exceedingly long and narrow, their lengths in a male specimen being 17 and 18 mm., respectively, with an average width of 0·3 mm. Their ground tissue, as seen in transverse section (fig. 15), resembles that of the innermost layer of the subcuticula. There is a distinct, relatively thick, external limiting membrane. The single central lacuna of each appears to be more definitely bounded by a delicate membrane when compared with those of the body wall. Each lemniscus has numerous nuclei, especially towards the anterior end.

In both sexes the genital ligament arises from the posterior end of the proboscis sheath and extends backward through the entire body length. Several

strands of muscle fibres pass from it to the body wall at the posterior end. The ligament itself is composed of a few muscle fibres embedded in a filmy protoplasmic strand.

MALE SYSTEM.

The two oval testes, measuring about 0·5 by 0·3 mm., lie one behind the other in the anterior third of the body. Each is enclosed in a capsule formed by the genital ligament, and from the posterior end of each capsule there arises a single vas efferens. There are six very long, narrow prostate glands whose length in the specimen measured was 12 mm., the diameter of each being about 0·1 mm. These glands commence at about the level of the posterior testis and pass backward, side by side, within the genital ligament. In section they are irregularly rounded, with an approximately central lumen, filled with a granular and strongly eosinophil prostate secretion. The surrounding syncytial tissue contains numerous typical nuclei in a fibrous matrix. Small granules, and groups of granules, are scattered through this matrix, but the area immediately surrounding the lumen is comparatively clear (fig. 11).

The vasa efferentia travel separately within the ligament for about two-thirds the length of the prostate glands, when they unite to form a single vas deferens. The latter, which shows one or two small swellings along its course, passes backward to the apex of the large muscle-sac or markbeutel, where it expands to form a club-shaped vesicula seminalis. From the latter a convoluted ductus ejactulatorius passes through the tissue of the median lobe of the bursa to the male opening.

At the apex of the markbeutel the prostate glands join to form a single muscular prostate duct. In most of the preparations examined this was in a contracted state and contained no secretion, so that it was indistinguishable in whole mounts from the strand of muscle passing from the base of the markbeutel to the body wall and overlying it. This duct opens into a large bilobed prostate reservoir which envelopes the vesicula seminalis and extends laterally on both sides of the markbeutel. At its base the reservoir opens into the ductus ejactulatorius. These structures are shown in a reconstruction in fig. 21, and the relations of the vesicula seminalis, prostate reservoir and ejaculatory duct, in more detail, in fig. 20. No genital ganglion was observed.

The copulatory bursa is a large thin-walled structure which, when withdrawn within the body, is very much folded and puckered. It is lined by a thin cuticle, but there are no lacunae in its subcuticula. At the posterior end the wall of the bursa is continuous with that of the posterior or genital sphincter. The latter is a single muscle cell with a peculiar "frothy" protoplasm surrounding a strongly cuticularised, narrow, winding tube which forms the external genital opening when the bursa is retracted; when the latter is everted it protrudes through this aperture as a bell-shaped organ with a pronounced thickening of part of the wall forming a kind of central lobe or fold projecting into its lumen, while the markbeutel and associated structures become approximated to the inner side of the genital sphincter, and the actual aperture of the male duct becomes carried forward through the sphincter and lies within the everted bursa. In many specimens, not only is the bursa retracted, but as much as three or four millimetres of the body wall may be invaginated, so that the genital sphincter comes to lie at a corresponding distance from the posterior end of the specimen. As a result, there are three possible positions of the male complex, with intermediate connecting stages. Fig. 4 shows the arrangement in a state of extreme retraction, as does the section in fig. 19, where the pushing down of the sphincter into the apex of the invaginated region causes it to simulate a penis. Figs. 5 and 6 and the reconstruction shown in fig. 21 indicate the bursa retracted but with the sphincter terminal; while figs. 28, 29 and the section in fig. 20 show the bursa everted through the sphincter.

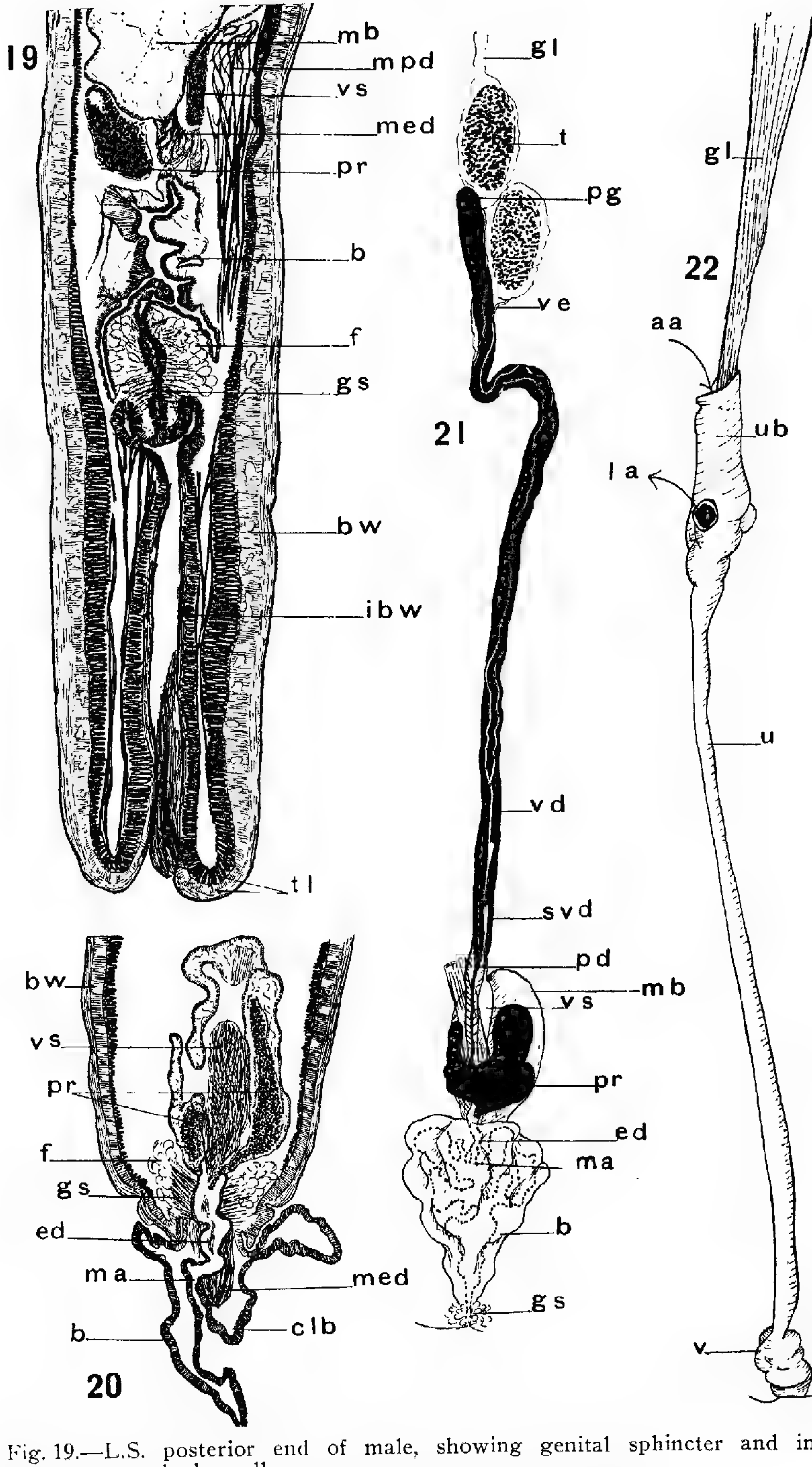

Fig. 19.—L.S. posterior end of male, showing genital sphincter and invaginated body wall.

Fig. 20.—Ditto, somewhat diagrammatic, with bursa extruded.

Fig. 21.—Reproductive system of male, greatly folded walls of bursa indicated by dotted line.

Fig. 22.—Reproductive system of female.

Female System.

In the gravid female the uterine bell, uterus and vagina together measure about 4 mm. in length. The bell consists mainly of one large muscle cell enclosing a cavity into which the genital ligament passes to become attached at the base. There are, in addition, a few much smaller cells forming the posterior region of the bell. Besides the wide anterior opening there are two ventro-lateral apertures leading to the body cavity, each within a lateral muscle cell (fig. 23). From the cavity of the bell two other openings, each within its own lateral muscle cell, lead into the uterus, their position being shown in figs. 24 and 25. This arrangement is essentially similar to that described by Kaiser (1893, pl. 7, figs. 11-16; pl. 8, figs. 2, 37), as occurring in five different species, which have since been allotted to *Acanthocephalus*, *Macracanthorhynchus*, *Corynosoma* and *Bolbosoma*. The uterus is a long, narrow tube with muscular walls, and is usually filled with eggs. In the short, swollen vagina which succeeds it, two sphincters, an anterior and a posterior, can be recognised. Investing the lower tenth of the uterus is a pair of elongate cells, probably glandular, lying between the lumen and the muscle cell of that portion of the duct—in other words, these two cells are actually enveloped by the terminal muscle cell of the uterus. Then follows a similar, though very much smaller, cell lying between the muscle cells of the vaginal sphincter and the lumen of the vagina, and actually surrounding the latter. This is succeeded by a large cell, apparently of the same nature as the others, surrounding the female aperture. The last-mentioned cell differs from the others in form, since it possesses a transverse diameter greater than its length and approximately the same as that of the mass of sphincter cells surrounding the preceding portion of the vagina (fig. 26).

Eggs from the uterus range from 0·07 to 0·087 mm. in length, and from 0·025 to 0·027 mm. in diameter. There are three shells, of which the middle one is constricted near each end to form a polar pouch which measures about one-seventh its length. All eggs observed in the uterus were in the two-celled stage (fig. 27).

In figs. 32, 33, 34, two individuals are indicated in copula. These were cleared in methyl salicylate, and some details were observed. The bursa was seen to have been protruded through the genital sphincter, carrying with it the mass of tissue which projects into the cavity of its bell and contains the ejaculatory duct (cf. fig. 20). This projection fitted into the latero-terminal depression of the female, while the end of the latter was surrounded very closely by the bursa.

Systematic Position.

In 1911 Lühe restricted the old genus *Echinorhynchus* very considerably, after separating off from it a number of species which he allotted to new genera, *Plagiorhynchus* being amongst them. He mentioned that the species retained were parasitic in the intestine of fish, and Van Cleave (1923, p. 185) has apparently adopted the same view. *Plagiorhynchus* was erected to include related parasites of birds which differed from *Echinorhynchus*, sensu stricto, in possessing long finger-like lemnisci, a more or less oval body, and eggs with characteristic polar swellings. This genus is regarded by Van Cleave and Travassos (1926) as valid, but Southwell and Macfie (1925, 177) quote it as a synonym of the latter.

The species from the black snake possesses some well-marked characters, such as the short, spherical proboscis, the exceedingly long lemnisci, the anterior position of the testes, and the very long, narrow, tubular prostate glands, while the eggs are intermediate in form between those of *Echinorhynchus* and *Plagiorhynchus*. These differences appear to us to be of sufficient value to justify generic separation. We therefore propose to erect a new genus, *Sphaerechinorhynchus*, for which the following diagnosis may be offered:—Echinorhynchidae; near *Echinorhynchus* and *Plagiorhynchus* (as defined by Lühe and Van Cleave);

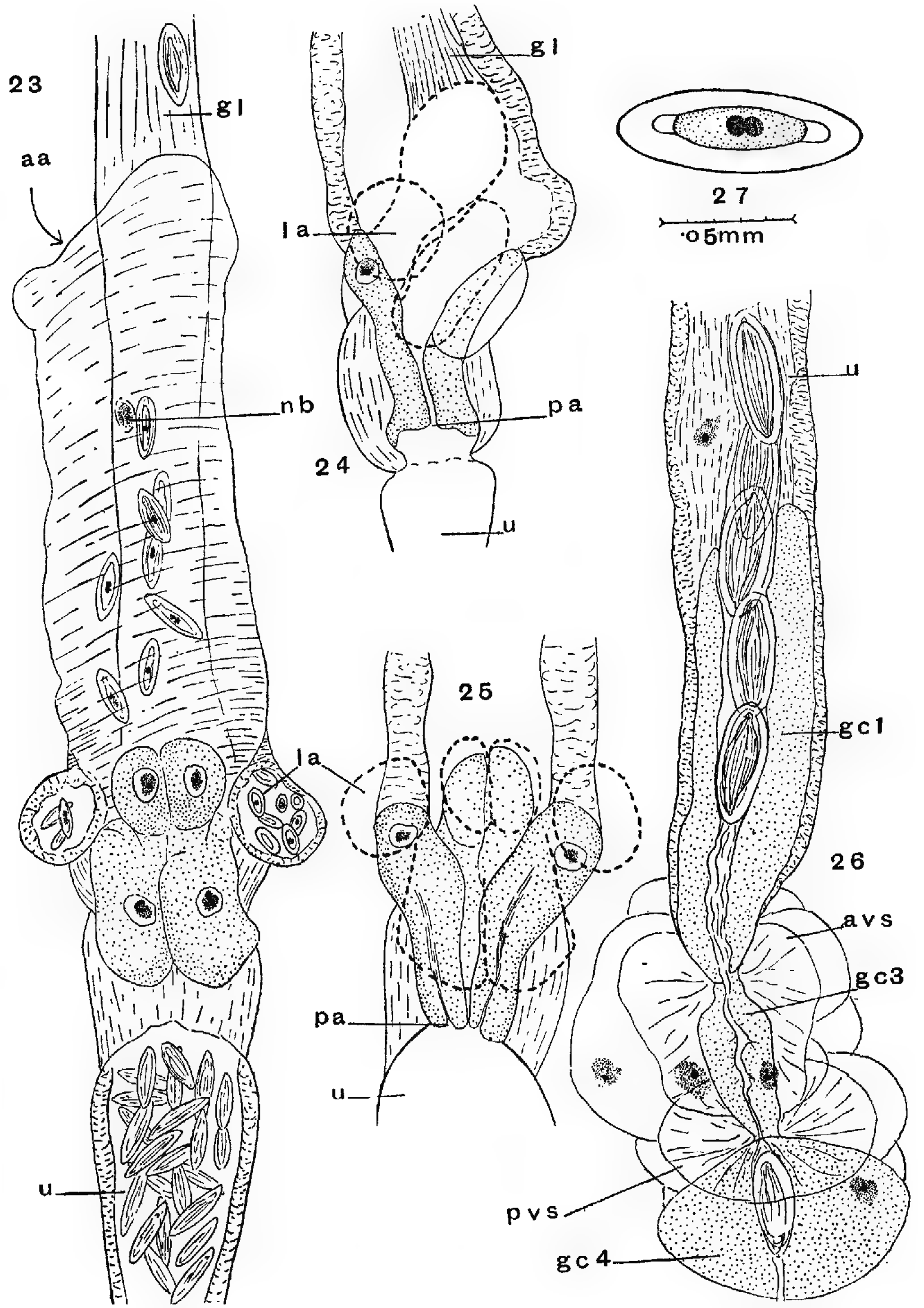

Fig. 23.—Uterine bell.
Fig. 24. -Lateral view of bell in optical section, dotted lines indicate cells shown in fig. 23.
Fig. 25.—Face view of bell in optical section. Figs. 23, 24, 25 are at same magnification.
Fig. 26.—Posterior end of uterus and vagina.
Fig. 27.—Egg.

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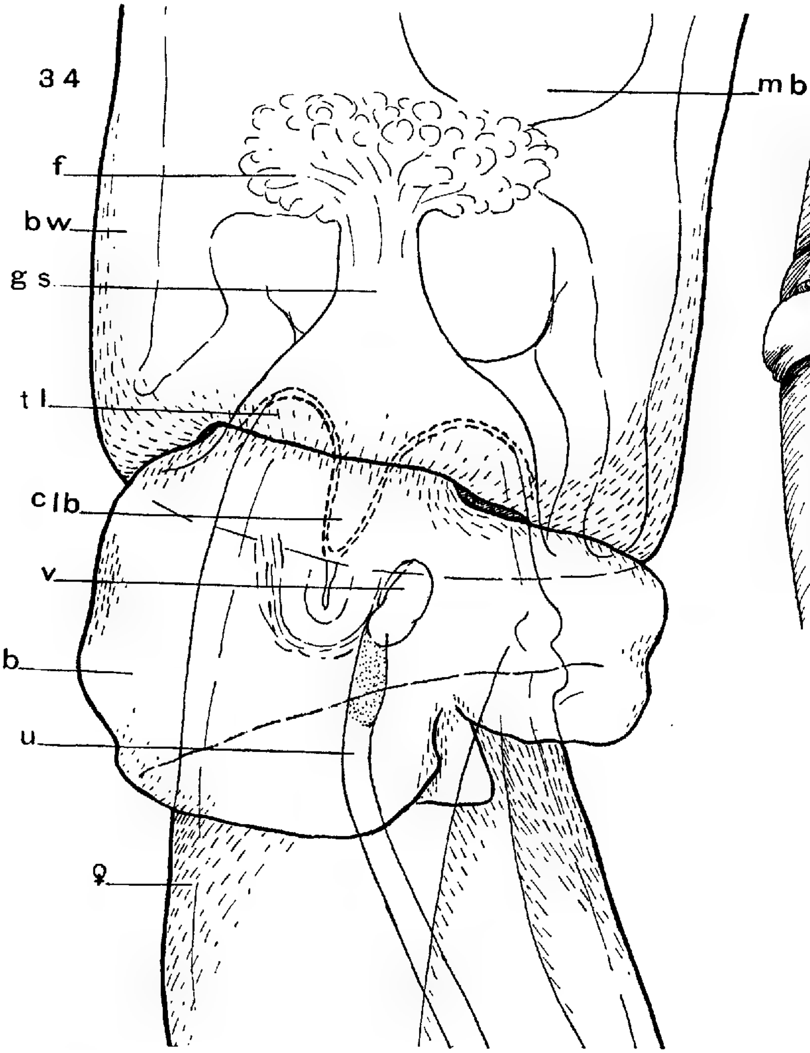

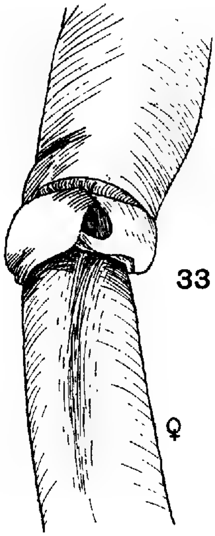

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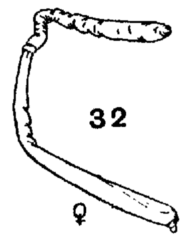

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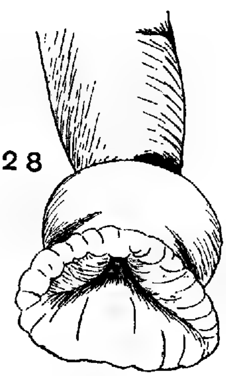

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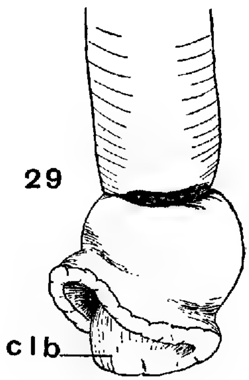

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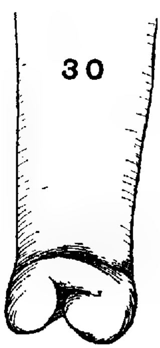

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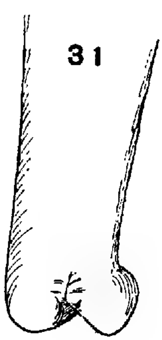

Figs. 28, 29.—Front and lateral views of everted bursa.
Figs. 30, 31.—Ditto of posterior end of female.
Fig. 32.—Two individuals in copula, about natural size.
Fig. 33.—Ditto, posterior end of each, magnified.
Fig. 34.—Ditto, cleared and viewed as transparent objects, more highly magnified.

small to medium size; body devoid of spines; proboscis short, more or less spherical, with numerous hooks diminishing in size posteriorly and possessing simple roots; numerous small nuclei in subcuticula; proboscis sheath double-walled and inserted at base of proboscis; ganglion near middle of proboscis sheath; retinacula arising from side wall of sheath; lemnisci relatively very long, more than two-thirds the length of body; testes in anterior third of body; prostate glands, six, very long, narrow, tubular. Type, *S. rotundocapitatus* (Johnston 1912) Johnston and Deland 1929, from the black snake, *Pseudechis porphyriacus*.

Explanation of Lettering.

aa, Anterior aperture of uterine bell; avs, anterior vaginal sphincter; b, bursa; br, brain; bw, body wall; c, cuticle; cf, circular fibrils; cfl, coagulated fluid; cl, central lacuna; clb, central lobe of bursa; cm, circular muscle; ct, capsule of testis; ed, ejaculatory duct; f, "frothy" protoplasm of genital sphincter; gc 1, gc 3, gc 4, gland cells of the vagina; gl, genital ligament; gs, genital sphincter; h, hook; ibw, invaginated body wall; ips, inner proboscis sheath; l, lemniscus; la, lacuna; lab, lateral aperture of uterine bell; ll, longitudinal lacuna; lm, longitudinal muscle; m, contractile part of muscle cell; ma, male aperture; mb, markbeutel; med, muscular tissue surrounding ejaculatory duct; ml, limiting membrane; mpd, muscular wall of prostate duct; n, nucleus; nb, nucleus of large muscle cell of uterine bell; nc, nucleolus; nf, nerve fibre; ops, outer proboscis sheath; p, proboscis; pa, posterior aperture of uterine bell; pd, prostate duct; pm, protoplasmic part of muscle cell; pr, prostate reservoir; prp, protoplasmic part of retractor muscles; ps, proboscis sheath; pvs, posterior vaginal sphincter; rp, retractor muscle of proboscis; s, prostate secretion; sc, subcuticula; sl, striated layer; svd, swelling on vas deferens; t, testis; tl, terminal lobes of body wall; u, uterus; ub, uterine bell; v, vagina; vd, vas deferens; ve, vas efferens; vs, vesicula seminalis.

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NOTES ON THE GEOLOGY OF THE GREAT PYAP BEND (LOXTON), RIVER MURRAY BASIN, AND REMARKS ON THE GEOLOGICAL HISTORY OF THE RIVER MURRAY.

By Professor Walter Howchin, F.G.S.

[Read July 11, 1929.]

Plates VI. to VIII.

Contents.

1. INTRODUCTION.

We are chiefly indebted to the late Professor Ralph Tate for a description of "The Physical and Geological Features of the Lower Murray River," published 53 years ago. [Trans. Roy. Soc. S. Austr., vol. vii. (1884-5), p. 24.] Tate's attention then, and subsequently, was principally directed to that portion of the river that extends from the North-West Bend (near Morgan), southward to the lakes, which presented a rare collecting field for Tertiary fossils. His knowledge of the river valley higher up than the North-West Bend seems to have been limited. In the paper just referred to he states: "That part of the river from the North-West Bend to the frontier was explored during a boat excursion occupying three weeks in the month of January of the present year" [1884]. I am not aware that Tate went over that ground a second time.

Tate divided the South Australian portion of the Murray Basin into three distinct geological sections:—

(1) A Lower Lacustrine area, taking in the lakes situated between Wellington and the mouth of the river.

(2) The Gorge, cut in the fossiliferous Tertiary beds by a retreating waterfall, extending from Lake Alexandrina to Overland Corner.

(3) An Upper Lacustrine area, consisting, chiefly, of fresh-water sands; forming a "minor plateau," more or less subject to overflow, extending from Overland Corner to the New South Wales border.

The observations recorded in the present paper were made in August, 1915, and are supplementary to those published by Tate. The river cliffs examined extend for about four miles (one and a half miles above Loxton, and two and a half miles below that township), taking in the most southerly portions of the Great Pyap Bend of the river. The geological formations, within the range stated,

can be referred to two distinct ages—the lower beds representing the Marine Miocene System; and the upper, fluviatile or lacustrine sediments, probably of Newer Pleistocene age.

2. MIOCENE FOSSILIFEROUS BEDS.

Tate, in describing a river "cliff at 101 miles from Blanchetown," says: "This last section is instructive, as it is the only one known to me in which the actual superposition of the sharp fluviatile sands upon the marine beds is visible, though the same phenomenon may be inferred at Overland Corner. This section is distant in a straight line from Overland Corner four miles only, and yet in that short distance the whole character of the stratigraphy has changed" [*loc cit.* p. 42].

We have now to record the presence of the fossiliferous Miocene in outcrop as far up the river as Loxton (pl. vi., fig. 1), situated at the head of the Great Pyap Bend. The river was, unfortunately, in flood at the time of my visit, and, as the lower portions of the cliff were submerged, it made the examination of the beds near the water line rather hazardous. The following localities for the fossiliferous outcrops were noted:—

(1) At Loxton these beds are exposed in a small washout in the cliff, where a rotten, argillaceous, dark-coloured bed contains shells in a bad state of preservation, mostly broken and decomposed to a chalky condition. The only recognisable forms were *Ostrea,* sp., and *Crassatellites communis* Tate. The bed is also exposed on the pathway by the side of the river, but, having been subjected to wear from traffic, most of the fossil remains had been reduced to fragments. The matrix could be correlated with exposures of a more definite character referred to below.

(2) About a mile down the river from Loxton, at the most southerly bend of the river (pl. vi., fig. 2), a small exposure of the Miocene beds was observed in the bank, near the water's edge. A local resident informed me that when the water was low the rock with shells was much better seen.

(3) At the next southerly bend of the river, about one and a half miles from the last-mentioned locality, a much better outcrop appears in which about ten feet of a similar argillaceous fossiliferous bed was exposed in the face of a steep bank and passed below water level. Among the fossil forms noted were *Cellepora gambierensis* (very common), *Retepora,* sp., *Flabellum,* sp., *Ostrea,* sp., *Crassatellites communis* (common), *Trigonia acuticostata,* and *Hinnites corioensis.* The exposure appeared to be continuous for another mile down the river (pl. vii., fig. 1), but had not the opportunity of following it further.

Information in the offices of the Engineer-in-Chief's Department shows that, at seven miles above Loxton, a fossiliferous clay occurs from about low-water level in the banks, down to about 28 feet in the bed of the river; and at about 17 miles above Loxton there are fossiliferous beds just below river low-water level at a height of only 33 feet above sea level.

3. RIVER ALLUVIA.

These are well developed near Loxton in cliffs that reach a height of about 80 to 100 feet. The deposits consist mainly of sands of various colours and degrees of fineness that are sometimes cross-bedded. Layers of small-sized gravel occur occasionally, the pebbles averaging in size about half an inch in the long diameter —rarely reaching a length of one inch. Coarse angular grits are common with an average size of one-eighth of an inch, rounded on their edges and angles. Coarse and fine sharp sands, passing into very fine whitish sand with fine flakes of clastic

mica scattered over the bedding planes, sufficient in some cases to give the rock a fissile character.

The sands are, for the most part, very loosely cemented and friable. In some layers there is sufficient clay in the interstices to give an adhesive quality to the stone by which it can be easily handled. In places a strong cement of hydrous oxide of iron has consolidated the bed, giving the rock every shade of colour from a dark brownish-red to bright red or yellowish, which, in the finer sediments, becomes a freestone. About a mile above Loxton there has been an extensive infiltration of silica that has converted the grits into a very siliceous rock, slightly coloured by the presence of iron oxide. Although the stone is very hard it can be broken easily by the hammer, with a conchoidal fracture, and is quarried for use as a building stone. This silicification of the fluviatile sediments extends along the cliffs for about a third of a mile. It begins and ends rather abruptly, and has a thickness up to 20 feet. Transverse lines of erosion expose the rock in large masses (pl. vii., fig. 2), and shows that it extends back from the cliffs for, at least, several hundred yards. The cutting of a shelf in the face of the river cliff for the placing of the Loxton Pumping Works (pl. viii.) has made a clean exposure of the upper portion of the fresh-water beds.

4. FRESH-WATER LIMESTONE.

The river cliffs, near Loxton, carry another feature of interest in the occurrence of an argillaceous limestone containing fresh-water shells. The layer varies from two feet to three feet in thickness, and is situated near the top of the cliff-face at a height of about 70 or 80 feet above the river level. It can be well seen in the cliff immediately behind the Waterworks Pumping Station (shown in the photograph, plate viii., as a white band), from which point it passes up the river for about half a mile; large blocks of the limestone that have broken away from the parent rock lie at the base of the cliff. Grains of fine sand are scattered through the limestone, and may be in sufficient numbers, in places, to give the features of an arenaceous limestone. On the application of HCl a brisk effervescence follows, leaving an insoluble residue of clay and fine sand. The shelly material has been removed by solution, leaving cavities between the internal casts and the external impressions. No remains of bivalves were seen in the bed, but from the casts of gasteropods Mr. B. C. Cotton, of the conchological department of the South Australian Museum, recognises the genera, *Bulinus, Physa,* and, possibly, *Paludina.* The limestone is underlain by coarse sands and grits, and is overlain by surface travertine and reddish soils and sands of varying thickness.

5. THE DESERTED RIVER COURSE.

If Tate's theory, that the Murray, in its later stages, cut a new channel for itself be correct, and there is good reason to think that it is, there must have been an older outlet to the sea which is now deserted. This former channel is not likely to have been on the western side of the river, as there is high land in that direction, so attention has been directed to the country lying to the eastward and southward of the present river for evidence, if any, of a former channel.

The surface features of the Murray Plains are extremely monotonous and give little indication of what lies beneath the surface. Neither creek banks nor railway cuttings exist throughout the area from which information could be gathered. In a few places Pre-Cambrian rocks come near the surface, as do also the marine Tertiary beds, but the surface is almost uninterruptedly covered with a mantle of terrestrial origin. The one redeeming feature, in a geological sense, is that the country is thickly studded with wells and bores, from which some knowledge of the geological structure of the country can be obtained.

Transverse sections, based chiefly on government surveys for railways, show that the Murray Plains have a gradual rise from the River Murray to a low central plateau that has an average height of about 300 feet above sea level. Thus a line of section (see fig. 2) taken from Chucka Bend, joining on to the Paringa railway line, attains its maximum height of 252 feet at Wanbi, and then falls away to 121 feet at Meribah, near the border of Victoria. Another line taken from Tailem Bend to Pinnaroo (see fig. 3), rises gradually over a distance of about 55 miles when it reaches, approximately, the 300-feet level at the Cotton Bore, and rises gradually to a maximum of 350 feet at Hundred of Bews, and 344 feet at Pinnaroo, on the Border. On a north and south line (see fig. 5), starting at Loxton, at a height of 126 feet, it reaches the 300-feet level at the Anderson Bore, on the Peebinga railway line, about 50 miles to the southward of Loxton, passing through Cotton, at about the same elevation; it then slopes rapidly to Tintinara, at 62 feet above sea level, and to the Alfred Flat Bore, which is only a few feet above the Coorong.

In most cases throughout this area the fossiliferous Tertiary beds exist at depth. At a few places, as at the lower reaches of the Murray, at Swan Reach and Tailem Bend, the older [(?) Pre-Cambrian] rocks are at, or near, the surface. At Moorlands, near Tailem Bend, within 100 feet of depth there are fossiliferous Tertiary beds, under which is a lignitic fresh-water series, and this series rests on the Pre-Cambrian bed rock. The Cooke's Plains and Cotton bores bottomed on igneous rocks.

6. PARTICULARS OF BORES.

Over 40 bores have been utilized for the present purpose (see fig. 1 in text). These have been selected following, as near as possible, the railway lines, four sets running, approximately, in an east and west direction, and one north and south. A few others have been included that are irregularly placed.

As far as possible the heights of the bores above sea level have been given, based on the railway official figures, as well as the thickness of the respective geological systems that are represented, as far as could be recognised, in the logs officially published.

Unless otherwise stated, the borings were carried out by the Engineer-in-Chief's Department, the author being greatly indebted to the officers of this department for access to the official records and for copies of the published particulars of the borings. In many instances a fairly detailed log had been kept of the beds passed through, but as these logs have been compiled by workmen who had little specific knowledge of the scientific side of the question, the information is often imperfect and makes the scientific interpretation of the records somewhat difficult. For this reason the following attempts to define the respective geological horizons are open to revision.

It may be stated that the following rules have been adopted in distinguishing the fluviatile portions of the borings from the Tertiary beds which commonly underlie them:—

(a) Sand and superficial (travertine) limestone, variable up to 20 feet, are considered as Recent, terrestrial, and are so assigned in the bore sections.

(b) The fluviatile beds are supposed to be represented by the following terms used in the logs, *viz.*, "sand," "coarse sand," "grits," "red sands," "yellow sands," "red-coloured clays," "gravel," "boulders," "micaceous sands and sandstones." The red-colouring matter is present mechanically caused by the contemporaneous infiltration of the hydrated oxide of iron, which is very characteristic of fresh-water deposits; as is also the presence of flakes of mica, which can be carried long distances in river transportation, but, from their soft and fragile nature, are almost immediately ground down to invisibility on the sea shore, and are, therefore, a very definite test of river sediments.

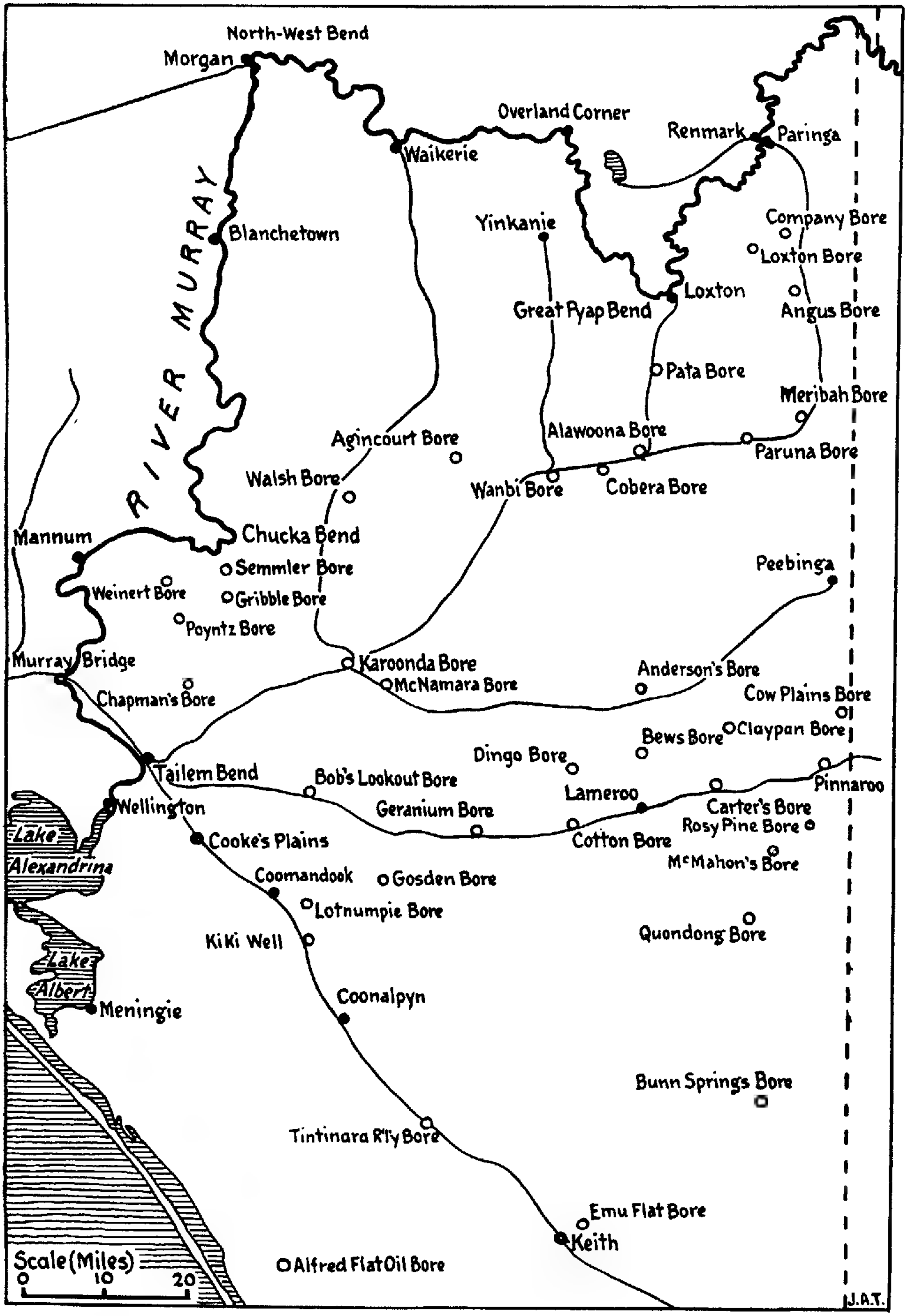

North-West Bend
Morgan
Overland Corner
Renmark
Paringa
Waikerie
RIVER MURRAY
Blanchetown
Yinkanie
Company Bore
Loxton Bore
Loxton
Great Pyap Bend
Angus Bore
Pata Bore
Meribah Bore
Alawoona Bore
Paruna Bore
Agincourt Bore
Walsh Bore
Wanbi Bore
Cobera Bore
Mannum
Chucka Bend
Semmler Bore
Peebinga
Weinert Bore
Gribble Bore
Poyntz Bore
Murray Bridge
Karoonda Bore
McNamara Bore
Anderson's Bore
Chapman's Bore
Cow Plains Bore
Bews Bore
Claypan Bore
Dingo Bore
Tailem Bend
Bob's Lookout Bore
Lameroo
Pinnaroo
Wellington
Geranium Bore
Carter's Bore
Rosy Pine Bore
Lake Alexandrina
Cooke's Plains
Cotton Bore
McMahon's Bore
Coomandook
Gosden Bore
Lotnumpie Bore
KiKi Well
Quondong Bore
Lake Albert
Meningie
Coonalpyn
Bunn Springs Bore
Tintinara R'ly Bore
Emu Flat Bore
Keith
Scale (Miles)
0
10
20
Alfred Flat Oil Bore
J.A.T.

Fig. 1.

(c) Beds of Tertiary age may be represented in the bores in one or other of two forms: Either by an upper series, which is marine, and often fossiliferous, or by an underlying series which is of fresh-water origin and generally carries some amount of lignite. The marine series is the more frequently present, as many of the bores did not penetrate so far as to reach the underlying fresh-water beds. The following terms were taken to include the marine series, *viz.*, all "limestones" below the surface travertine limestone, "calcareous sandstone," "cliff rock," "shell limestone," "marine" beds, and "sandstones" that occur overlying "fossiliferous" beds. In cases of doubt the associated beds have been taken into consideration. It is probable that a Kalimnan (Lower Pliocene) fossiliferous series occurs on top of the Miocene, in some of the bores, but as this series was not distinguished in the workmen's log from the older fossiliferous beds, they are included, if present, under the Miocene, as the more important of the two.

For convenience, as well as for consecutive representation, the bores dealt with in the present paper have been divided into groups as follow:—

[The division between the fresh-water and Tertiary beds is marked by a rule.]

Group I. (Fig. 2.)

The seven following records relate to a series of bores situated about 20 miles, or a little more, to the southward of Loxton, and extend, in an east and west direction, from within 16 miles of the River Murray, at Chucka Bend, on the west, to the borders of Victoria, on the east:—

1. Walsh Bore, situated a little to the eastward of the Karoonda-Waikerie railway, Hundred of Bandon. Height above sea level, approximately, 200 feet.

	Thickness, in feet.
Sand	1
Limestone	9
Red sandstone	12
Soft sandstone	52
Hard micaceous sandstone	45
———	
Freestone	19
Fossiliferous sandstone	3
Fossiliferous limestone	99
Fossiliferous sandstone	20
Total	260

Terrestrial, 10 feet; Fresh-water, 109 feet; Marine Tertiary, 141 feet.

2. Agincourt Bore, situated 14 miles to the eastward of Walsh, Hundred of Chesson. Height above sea level, estimated, 240 feet.

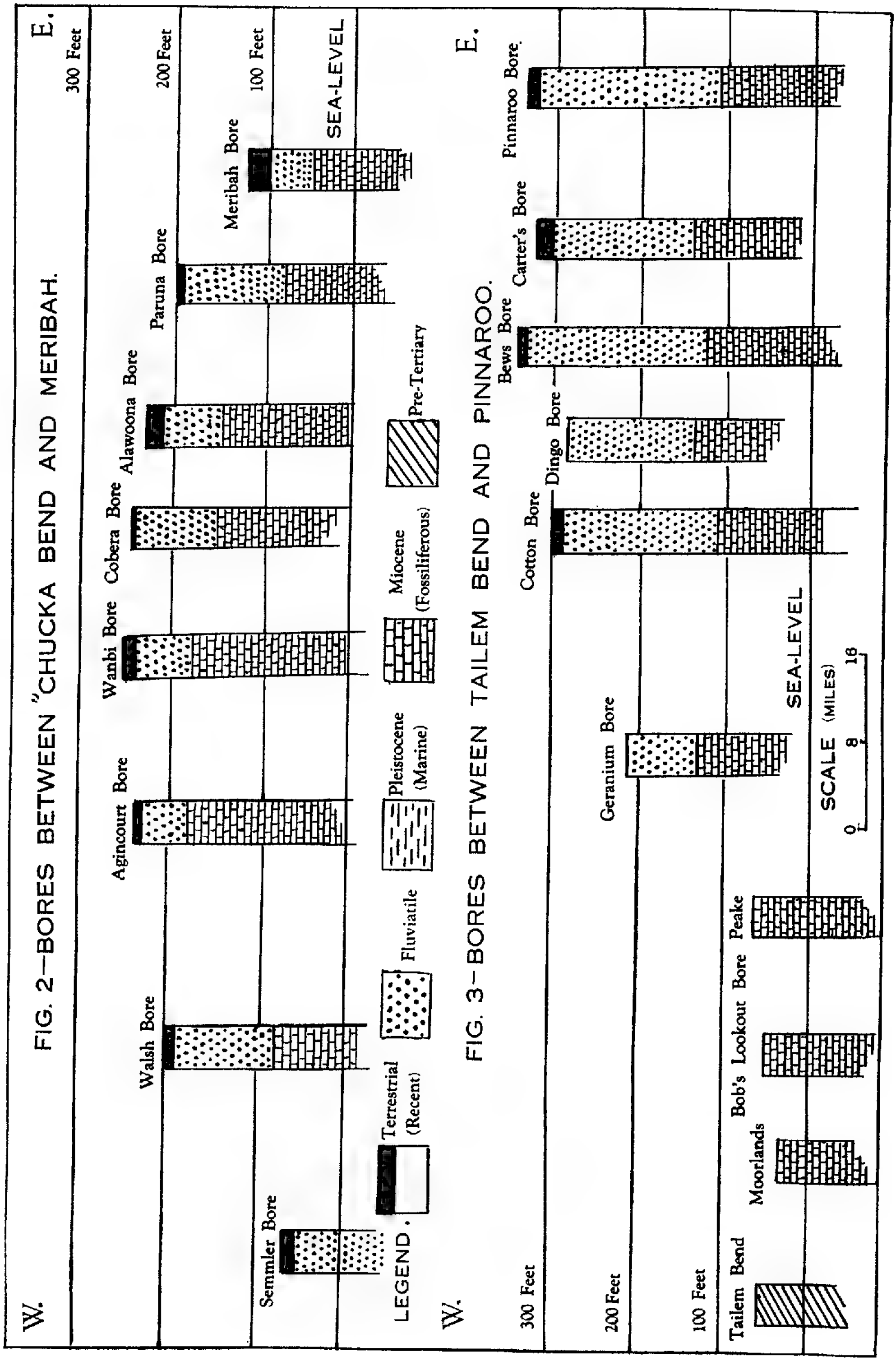
	Thickness, in feet.
Limestone rubble	5
Red sandy clay	5
———	
Sandstone	56
Calcareous sandstone, cliff rock	54
Sandstone	81
Shell rock	22
Total	223

Terrestrial, 5 feet; Fresh-water, (?) 61 feet; Marine Tertiary, (?) 157 feet.

3. Wanbi Bore, situated 12 miles to the south-eastward of Agincourt, on the Meribah-Renmark railway, Hundred of Mindarie. Height above sea level, 252 feet.

	Thickness, in feet.
Sand	3
Hard limestone	8
Tough red clay	20
Red sandstone	12
Yellow sandstone	33
———	
Hard calcareous sandstone	29
Soft sandstone	38
Marine clay and limestone	14
White clay	30
Shell rock	66
Total	253

Terrestrial, 11 feet; Fresh-water, 65 feet; Marine Tertiary, 177 feet.



Group I. (Fig. 2.)

Group V. (Fig. 3.)

4. Cobera Bore, situated six miles to the eastward of Wanbi, on the Meribah-Renmark railway, Hundred of Allen. Height above sea level, 252 feet.

	Thickness, in feet.
Sand	3
Red sandstone	13
Coarse sand	54
Fine micaceous sand	32
Limestone	31
Shell rock	85
Total	218

Terrestrial, 3 feet; Fresh-water, 99 feet; Marine Tertiary, 116 feet.

5. Alawoona Bore, situated six miles to the eastward of the Cobera Bore, at the junction of the railway for Loxton. Height above sea level, 231 feet.

	Thickness, in feet.
Sand	4
Sandy clay	3
Limestone rubble	8
Red clay	15
Soft sandstone	29
Hard red sandstone	16
Tough yellow clay	7
Cemented quartz gravel	4
Calcareous sandstone, cliff rock	20
Cemented quartz gravel	14
Calcareous sandstone, cliff rock	26
Marine clay	7
Fossiliferous sandstone	18
Marine clay with shells	7
Sandstone	1
Light blue clay	18
Shell rock	14
Total	211

Terrestrial, 15 feet; Fresh-water, 71 feet; Marine Tertiary, 125 feet.

6. Paruna Bore, situated 13 miles eastward of Alawoona, on the railway. Height above sea level, 193 feet.

	Thickness, in feet.
Sand	2
Limestone	2
Fine sand	46
Coarse sand	70
Hard sandstone	8
Marine clay and shells	107
Shell rock	24
Total	259

Terrestrial, 4 feet; Fresh-water, 116 feet; Marine Tertiary, 139 feet.

7. Meribah Bore, situated on the railway to Renmark, at the angle near the Victorian border. Height above sea level, 121 feet.

	Thickness, in feet.
Yellow sand	12
Limestone	8
Yellow siliceous sand	27
Brownish siliceous sand	6
Yellowish siliceous sand	7
Coarse sand and grits	5
Greyish sand	7
Calcareous clay, shelly	98
Shell bed	5
Limestone	11
Polyzoal limestone	60
Total	246

Terrestrial, 20 feet; Fresh water, 52 feet; Marine Tertiary, 174 feet.

Group II.

This group includes four borings situated on the Karoonda to Peebinga railway, roughly parallel with the preceding:—

1. Karoonda Bore, near the railway junction for Waikerie and Peebinga. Height above sea level, 223 feet.

	Thickness, in feet.
Limestone marl	5
Red sandstone	48
Micaceous quartz conglomerate	21
Sandstone	5
Sand and gravel	15
Sandstone	22
Clay	7
Calcareous sandstone	27
Shell rock	34
Total	184

Terrestrial, 5 feet; Fresh-water, 89 feet; Marine Tertiary, 90 feet.

2. McNamara Bore, situated a few miles to the eastward of the preceding, near the railway. Height above sea level, approximately, 223 feet.

	Thickness, in feet.
Surface loam	1
Clay and Limestone	4
Sandy Clay	39
Coarse sand and gravel	10
Quartz sand	25
Yellow micaceous sandstone	11
Dark sand with mica	3
Yellow sandstone with hard bands	27
Clay with fossil shells	16
Fossiliferous sandstone	10
Shell rock	35
Total	181

Terrestrial, 5 feet; Fresh-water, 88 feet; Marine Tertiary, 88 feet.

3. Anderson Bore, in Hundred of Bews, near Wirha, on the Peebinga railway, approximately 300 feet above sea level.

	Thickness, in feet.
Sand	1
Yellow sandstone	34
Sand	15
Yellow sandstone	38
Coarse quartz sand	42
Fine micaceous sandstone	45
Sandy clay and shells	17
Fossiliferous limestone	60
Total	252

Terrestrial, 1 foot; Fresh-water, 174 feet; Marine Tertiary, 77 feet.

4. Karte Bore, in Hundred of Kingsford, 13 miles to the eastward of the Anderson Bore. Height above sea level, 279 feet.

	Thickness, in feet.
Grey sand	60
Red sand	20
Coarse sand	30
Sandy clay	20
Quartz gravel	20
Fine grey sand	20
Sandstone	15
Marine clay	18
Coralline limestone	47
Total	250

Fresh-water, 170 feet; Marine Tertiary, 80 feet.

Group III.

To the westward of Groups I. and II. are five other bores, situated nearer to the River Murray, and having a north and south direction. These are:—

1. Semmler Bore (within a few miles of Chucka Bend).

	Thickness, in feet.
Sand	2
Marly clay	10
Red sand	48
Hard red sandstone	2
Yellow sand	33
Sand and boulders	138
Brown sand	5
Sand and limestone	18
Clay	4
Hard micaceous sandstone	5
Yellow sand	8
Hard micaceous sandstone	7
Coarse water-worn sand and pebbles	4
Micaceous sand	3
Sandy clay	8
Soft sandstone	79
Total	374

Terrestrial, 12 feet; Fresh-water, 221 feet (or more); Tertiary, (?).
[See forward, p. 187.]

2. Weinert Bore. A little to the westward of the Semmler Bore, but more distant from the river.

	Thickness, in feet.		Thickness, in feet.
Loam and limestone rubble	4	Sandstone	150
Sandy clay	11	Shell rock	36
Red sandstone	80	Clay with fossil shells . .	74
Sandstone and boulders	27	Grey sandy clay	10
Sand	18	Fine sand	1
Boulders	10		
		Total ...	421

Terrestrial, 4 feet; Fresh-water, 146 feet; Marine Tertiary, 271 feet.

3. Gribble Bore, situated a little to the southward of the Semmler Bore.

	Thickness, in feet.		Thickness, in feet.
Limestone .. .	9	Sand and limestone	33
Red clay	7	Yellow sandstone	128
Red sandstone	27	Freestone	50
Yellow sandstone	26	Fossiliferous sandstone	40
		Total	320

Terrestrial, 9 feet; Fresh-water, 60 feet; Marine Tertiaries, 251 feet.

4. Poyntz Bore, situated about six miles south-westward of the preceding.

	Thickness, in feet.		Thickness, in feet.
Sand and limestone ...	18	Sandy clay with shells	48
Sand and quartz	18	Sand, shells, and ironstone	5
Freestone	10	Dark sand	9
Sand and lime	8	Sa, dstone	16
Soft sandstone with fossil shells	105	Clay and lignite	52
Limestone	12	Micaceous sandstone	23
Yellow sandy clay	9	Clay with pyrites	5
		Total	338

Marine Tertiary, (?) 258 feet; Fresh-water Lignitic Series, (?) 80 feet.

5. Chapman Bore, situated about nine miles southward of the preceding, and 15 miles due east of Murray Bridge.

	Thickness, in feet.		Thickness, in feet.
Sand	4	Sandy clay	32
Limestone	8	Dark clay	23
Freestone	44	Soft sandstone	21
Calcareous sandstone	14	Hard sandstone	11
Sandy clay	43	Clay and ironstone	5
Freestone	67	Light decomposed slate	74
		Total	346

Marine Tertiary, 272 feet; Pre-Tertiary, 74 feet.

Group IV.

This group includes four bores situated about midway between the Peebinga and Pinnaroo railway lines, towards the eastern side of the map:—

1. Cow Plains Bore, situated on the boundary of the State, about seven miles to the northward of Pinnaroo.

	Thickness, in feet.		Thickness, in feet.
Loam and marly clay	10	White sand	10
Clay	4	Red sand	10
Sandstone	19	Yellow sand	8
Sandy clay	4	Coarse red sand	15

	Thickness, in feet.
Dark coarse sand	20
Fine white sand	30
Fine yellow sand	20
Sand & ironstone boulders	5
Limestone	5
Sand, clay and shells	40
Sandstone and shells	11
Fossiliferous limestone	6
Total	217

Terrestrial, 10 feet; Fresh-water, 145 feet; Marine Tertiary, 62 feet.

2. Clay Pan Bore, Hundred of Parilla. About 340 feet above sea level.

	Thickness, in feet.
Clay	10
Sandstone	36
Sand	108
Micaceous sand	6
Sand	48
Sandy clay	16
Limestone and shells	10
Total ...	234

Apparently in Fresh-water Series, except the final 10 feet.

3. Hundred of Bews Bore (about 350 feet above sea level; Bews railway station is 290 feet).

	Thickness, in feet.
Sand	6
Sandy limestone	1
Sandstone	95
Sand	60
Clayey sandstone	8
Sand	31
Micaceous sandstone ..	9
Micaceous clay and sand	8
Sandstone	9
Fossiliferous limestone	123
Total	350

Terrestrial, 7 feet; Fresh-water, 211 feet; Marine Tertiary, 132 feet.

4. Dingo Bore (about 300 feet above sea level), situated nine miles to the westward of Bews Bore.

	Thickness, in feet.
Light and red clay	3
Ironstone conglomerate	7
Soft sandstone	43
Hard sandstone	32
Sand	26
Sandstone	22
Fine sand and ironstone conglomerate	16
Ironstone conglomerate and sandy clay	4
Red sandy clay	9
Black sand with shells	25
Limestone with shells	37
Total	224

Fresh-water, 162 feet; Marine Tertiary, 62 feet.

Group V. (Fig. 3.)

This group includes five bores, following the railway between Tailem Bend and Pinnaroo:—

1. Bob's Look-out Bore (about 50 feet above sea level), situated about 20 miles to the eastward of Tailem Bend.

	Thickness, in feet.
Marl	1
Limestone	43
Clay	10
Sand	3
Sandy clay and shells	12
Fine sand	9
Soft limestone	32
Hard grey rock	8
Sand and layer of hard rock	23
Light grey clay	36
Clay and lignite	93
Hard grey rock	1
Sand and shells	12
Total	283

In Marine Tertiary throughout.

2. Geranium Bore, 43 miles eastward of Tailem Bend. Height above sea level, 238 feet.

	Thickness, in feet.
Sandy clay	15
Sandy clay, sand, and soft sandstone	33
Micaceous sand	7
Micaceous sand and fine quartz gravel	15
Micaceous sand	3
Sand and limestone	20
Hard limestone and sandy clay	14
Soft limestone and shells	22
Hard limestone	5
Soft limestone	27
Soft fossiliferous limestone	7
Soft limestone and shells	3
Total ...	171

Fresh-water, 73 feet; Marine Tertiary, 98 feet.

3. Hundred of Cotton Bore (about 300 feet above sea level), eight miles westward of Lameroo.

	Thickness, in feet.
White sand	1
Brown clayey sand ...	1
Limestone rubble	1
Ironstone	5
Soft sandstone	30
Hard, coarse sandstone	112
Clay with ironstone nodules	40
Limestone	62
Limestone with shells ...	108
Calcareous sandstone	118
Hard, grey limestone	20
Dark clay and limestone....	10
Sandy limestone	14
Calcareous sandstone with fossils	15
Sand, clay, and pyrites	83
Sand	40
Dark clay	4
Grey sand and pyrites	16
Dark clay	10
Sand and fossils	14
Shelly sandstone	8
Black clay and fossils	13
Sandstone and clay .	9
Black shale	60
Black sand	6
Brown sand	14
Gravel and lignite	6
Micaceous sand	12
Rotten micaceous schist	7
Granitic sand	13
Granite	13
Total ...	865

Terrestrial, 8 feet; Fresh-water, 182 feet; Tertiary, 642 feet; Pre-Cambrian, 33 feet.

4. Carter's Bore, near Parilla (340 feet above sea level).

	Thickness, in feet.
Marly clay	16
Hard sandstone	36
Yellow sand	78
Red sand	40
Fine white sand	10
Yellow sandstone ..	59
Dark blue clay	11
Fossiliferous limestone ...	10
Total	260

Terrestrial, 16 feet; Fresh-water, 164 feet; Marine Tertiary, 80 feet.

5. Pinnaroo Bore, No. 2 (344 feet above sea level).

	Thickness, in feet.
Sandy loam	2
Travertine limestone	6
Coloured clay	42
Yellowish, argillaceous sand	10
Reddish argillaceous sand	18
Fine white quartz sand	3
Yellow argillaceous sand	21
Reddish argillaceous sand	10
Coarse quartz sand ..	13
Fine to coarse quartz sand	20
Medium quartz sand	25
Argillaceous sand with mica	5
Dark ditto, with mica	55
Tertiary fossiliferous limestone	5
Grey soft limestone ...	205
White chalky limestone	60
Polyzoal limestone ...	40
Grey porous limestone	30
White polyzoal limestone	30
Chalky limestone at 600 ft.	5
Total	605

Terrestrial, 8 feet; Fresh-water, 222 feet; Marine Tertiaries, 375 feet.

Group VI.

Includes four bores situated between the Pinnaroo and Serviceton railway lines, towards the eastern side.

1. McMahon Bore, situated on Section 10, Hundred of Pinnaroo, eight miles from the Victorian border.

	Thickness, in feet.
Limestone rubble	3
Clay	20
Fine sandstone	7
Coarse sandstone	150
Ferruginous sandstone	40
Dark blue clay	28
Fossiliferous limestone	56
Total	304

Terrestrial, 23 feet; Fresh-water, 197 feet; Marine Tertiary, 84 feet.

2. Rosy Pine Bore, situated to the south-eastward of the preceding, about three miles from the border.

	Thickness, in feet.
Marly limestone	3
Sandy limestone	17
Red and yellow limestone	58
White sand	12
Fine and coarse sand	100
Sand and ironstone	7
Sand	18
Clay and shells	15
Fossiliferous limestone	35
Total	265

Terrestrial, 20 feet; Fresh-water, 195 feet; Marine Tertiary, 50 feet.

3. Quondong Bore, situated between Bordertown and Pinnaroo.

	Thickness, in feet.
Sand	4
Clay	8
White sandstone	8
Yellow sandstone	19
Fine sand	26
Coarse sand	95
Freestone	70
Limestone	72
Total	302

Terrestrial, 12 feet; Fresh-water, 148 feet; Marine Tertiary, 142 feet.

4. Bunn Springs Bore, situated on the Bordertown to Pinnaroo route, about 10 miles from the Victorian border.

	Thickness, in feet.
Sand	2
Sandy clay	12
Sand and gravel	6
Red sandstone	76
Ferruginous sandstone	7
Red sand	15
Yellow sandstone	140
Fine yellow sandstone	52
Calcareous sandstone	20
Total	330

Fresh-water, 118 feet; Marine Tertiary, (?) 212 feet.

Group VII. (Fig. 4.)

The bores in this group follow the Tailem Bend to Bordertown railway line and district, in a south-easterly direction, parallel with the Coorong.

1. Cooke's Plains Bore, situated about 11 miles south-eastward of Tailem Bend. Height above sea level, 19 feet.

	Thickness, in feet.		Thickness, in feet.
Sand	2	Clay and gypsum	32
Soft limestone and gypsum	9	Fossiliferous limestone	10
Sandy limestone	39	Black clay	46
Gypsum	7	Sand & limestone boulders	3
Gypsum and sandy limestone	16	Hard clay	1
Gypseous rock	22	Igneous rock	6
Sandstone	31		
		Total ...	224

In the above bore three distinct formations are represented:—*(a)* An upper lacustrine, gypseous series of Recent age, having a thickness of 158 feet, underlying which are *(b)* Miocene marine beds, which are here reduced to a thickness of 60 feet; and these rest on *(c)* bed-rock, probably of Pre-Cambrian age. As bearing on the origin of the upper, lacustrine beds, Tate describes [Trans. Roy. Soc. S. Austr., vol. iv., 1882, p. 144] two sections seen on the shores of Lake Alexandrina, near Wellington, in which gypseous deposits are especially prominent. It is, therefore, probable that the upper portion of the Cooke's Plains sediments represents a former extension of Lake Alexandrina in that direction.

2. Coomandook Bore, situated on the line, 21 miles from Tailem Bend. Height above sea level, 40 feet.

	Thickness, in feet.		Thickness, in feet.
Sand and clay	29	Coralline limestone	7
Limestone and shells	32	Sandy clay	3
Sandstone	45	Ligneous clay	79
Marine clay	12	Sand	5
Clay and sand	10	Dark clay	4
Hard blue limestone	60	Sand and quartz	8
Clay and gypsum	10	Clay, sand and pebbles ..	48
Sandy clay	23	Sandy clay	17
Ligneous clay	20		
		Total	412

Marine Tertiary resting on Lignitic (Fresh-water) Series.

3. Ki Ki Bore, situated between Cooke's Plains and Coonalpyn, 30 miles from Tailem Bend. Height above sea level, 92 feet.

	Thickness, in feet.		Thickness, in feet.
Limestone	2	Quartzose sand	30
White limestone	15	Black clay	7
Hard flinty limestone	10	Black clay and sand	14
Red quartzose limestone	10	Black clay	2
Soft whitish-yellow limestone	108	Dark grey clay	5
Soft limestone with marine fossils	70	White pipe clay	3
Hard sandstone	2	Dark clay and sand .	1
Soft limestone with marine fossils	63	White pipe clay	48
Calcareous rock with marine fossils	45	Yellow pipe clay	31
Dark grey rock with marine fossils	15	Pink pipe clay	3
Black clay	20	Yellow and pink pipe clay	43
Sand	1	Rotten reddish-brown clay rock	2
Black clay	19	Rotten yellowish - green clay rock	5
Quartzose sand with fossils	4	Very soft dark-green clay rock	63
Black clay	11	Hard slaty rock with quartz	14
		Total	666

Marine Tertiary resting on decomposed slate rocks, passing down to unaltered slate.

4. LOTNUMPIE BORE, situated about four miles due north of Ki Ki. Height above sea level, 98 feet.

	Thickness, in feet.
Travertine limestone	8
Yellowish sand	20
Argillaceous limestone	9
White calcareous sandstone	45
Calcareous sand	18
Sand with shell fragments	5
Shell limestone	2
Sand with shell fragments	21
Shell limestone	27
Fine sand with shell fragments	2
Shell limestone	82
Sandy clay with shells	44
Hard fossiliferous limestone	1
Limestone with echinoderms	5
Polyzoal and echinoderm limestone	13
Total	302

Marine Tertiary, capped by Travertine.

5. GOSDEN BORE, situated about 9 miles to the north-eastward of the preceding.

	Thickness, in feet.
Limestone	39
Fossiliferous limestone	51
Sand and pebble	35
Sand and shells	25
Grey sand	15
Sand with rock layer	17
Grey sand	8
Sandy clay	30
Black clay	83
Coralline limestone	18
Clay with shells and pebbles	18
Blue clay	2
Lignite	19
Total	360

Marine Tertiary, resting on Lignitic (Fresh-water) Series.

6. COONALPYN (COLD AND WET) BORE, situated nine miles south-eastward of Ki Ki. Height above sea level, 72 feet.

	Thickness, in feet.
Brown clay with limestone crust	15
White limestone	3
Yellow sandstone	67
Sandstone with shells	20
Red clay	80
Black clay	5
Marine shell bed	34
Limestone with shells	11
Light grey clay	86
Chocolate clay	13
Sand	51
Quartz gravel and pyrites	4
Grey clay with lignite	4
Grey clay with gravel	11
Grey clay	26
Chocolate clay with gravel	6
Grey clay	4
Chocolate clay with gravel	40
Grey clay and slate, alternately	5
Hard blue slate	91
Do., with quartz veins	88
Hard blue slate	26
Do.	150
Total	840

The above section suggests 18 feet of Recent terrestrial deposits, 217 feet of fossiliferous Tertiary, 245 feet of fresh-water lignitic series; and these resting on slate rock that was penetrated to 360 feet, making a total depth of 840 feet.

[The Tintinara Bore, which occurs between the Coonalpyn and Emu Flat bores, will be considered with those taken in a north and south direction.]

7. Emu Flat Bore, situated about five miles to the northward of Keith railway station. Height above sea level, 101 feet.

	Thickness, in feet.
Light yellow sand	3
Light grey limestone	12
Soft yellow limestone	26
Light yellow limestone	12
Hard limestone	19
Light yellow calcareous sandstone	49
Soft grey limestone with marine fossils	22
Soft greenish limestone with fossils	30
Calcareous sand with marine fossils	36
Black clay, carbonaceous	21
Calcareous sand, marine fossils	22
Black clay, carbonaceous	12
Calcareous sand, marine fossils	5
Total	269

In Marine Tertiary throughout.

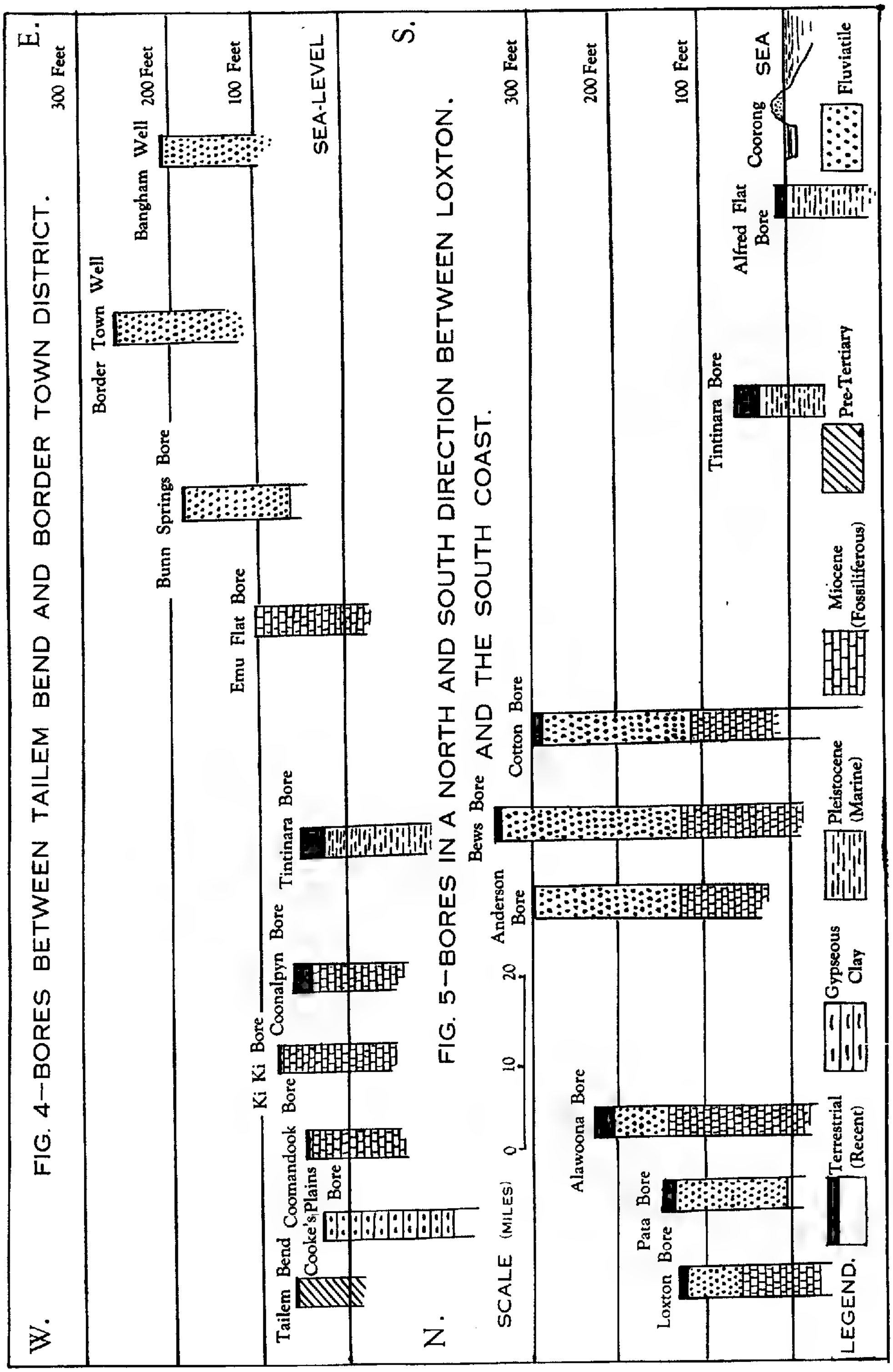
8. Bordertown and Neighbourhood. From the small number of bores sunk in the south-eastern part of South Australia, information concerning the rocks below the surface in that district is somewhat limited. Rev. Tenison Woods has published some observations on this subject which are of interest. He states: "Underneath the calcareous sandstone [indurated dune rock] we have in this district beds of coarse white, yellow, and red ferruginous sands, sometimes with layers of ironstone, and full of concretions of hydrated oxide and carbonate of iron. The thickness of the deposit varies in different places. At Bangham Pastoral Station, Tatiara [about 20 miles to the southward of Bordertown], I had an opportunity of descending a shaft sunk for water to a depth of 75 feet. The whole depth was occupied by beds of variegated sands of various thickness, the seams being somewhat lentil-shaped, as follow:—

	Thickness, in feet.
White sand	5
Ochreous red sand	10
Yellow sand	17
White sand	1
Red sand with ironstone concretions	1
Yellow sand	6
Brownish red sand	2
Yellow sand	10
White sand	5
Yellow sand	8
Coarse sand and clay	10
Water in clay	—
Total	75

"From a well sunk within a few miles of the above, I was able to see the junction between the coralline crags [Miocene] and the sands. The material composing the beds is a somewhat coarse siliceous sand, with much iron and sometimes rounded grains of pink felspar and mica." [Report on Geol. and Min. of the South-Eastern district of S. Austr., Govt. Printer, Ad., 1866, p. 13.]

As bearing on the same subject, Tate says: "The geological structure of the country which intervenes between the river at the [State] boundary and the Tatiara is, so far as I know, quite blank; but it is not unreasonable to suppose that the Newer Tertiary (fresh-water series) at these places is coterminous.[1] The Tatiara is an oasis on the edge of the mallee scrubs, in the one direction, and of the heath-lands of the South-East in the other; it owes its reputation to deep, loamy soils, the upper members of an extensive lacustrine deposit, as is partly revealed by a well-sinking at Bordertown, of which the following is a summary of the facts:—Pipe clay, 30 feet; diatomaceous earth, 21 feet; bituminous shale and clay, 40 feet. Total, 91 feet." [*Loc. cit.*, p. 43.]

[1] Tate's forecast, in this respect, has been amply confirmed by subsequent borings throughout this region.



GROUP VII. (Fig. 4.)

GROUP VIII. (Fig. 5.)

Group VIII. (Fig. 5.)

The following records of bores supply information of the beds penetrated in a north and south direction, from the Great Pyap Bend in the north to near the Coorong in the south. The first three bores are situated in the Hundred of Gordon:—

1. Loxton Bore (126 feet above sea level). Situated in Section 17, Hundred of Gordon. Particulars kindly supplied by Messrs. Clutterbuck Bros., who carried out the work in 1910.

	Thickness, in feet.
Sand and lime rubble	5
Red clay	8
Sand and red clay	10
Sand—dry	46
Coarse gravel	11
Black sand	68
Blue clay	70
Coral with streaks of blue clay	6
White clay	24
Blue clay with hard boulders	66
White sandy clay with boulders	91
Coral limestone with boulders	166
Hard blue boulders	13
Layers of hard rock	51
Blue sandy clay	43
Blue sticky clay	67
Brown sticky clay	13
Grey sand	19
Brown clay	8
Blue clay	16
Total	801

No fossil shells are mentioned in this log, and the presence of boulders from 248 feet to 584 feet, associated with "coral limestone," seems inconsistent with a fossiliferous marine bed, but the first 80 feet, ending in a bed of "coarse gravel," may be considered to be of terrestrial and fluviatile origin.

2. Angus Bore [(?) 85 feet above sea level].

	Thickness, in feet.
Sandy loam and limestone	5
Red clay	8
Sand	67
Fine micaceous sand	120
Sand and fossil shells	24
Argillaceous coralline limestone	24
Clay with layers of hard rock	66
Fine calcareous clay	109
Total	423

Terrestrial, 13 feet; Fresh-water, 187 feet; Marine Tertiary, 223 feet.

3. Company's Bore [(?) 79 feet above sea level].

	Thickness, in feet.
Sand and gravel	7
Red sandy clay	9
Clay, various colours	35
Indurated sand	14
Grey sand	9
Dark sand with boulders	23
Coarse sand and clay	31
Marine Tertiary	612
Lignitic Series	958
Blue shale (?) Pre-Tertiary	86
Total	1,784

Fresh-water, 128 feet (may include 28 feet more); Marine Tertiary, 612 feet; Lignitic (Fresh-water) Series, 958 feet; (?) Pre-Tertiary, 86 feet.

4. Pata Bore, situated about 10 miles due south of Loxton. Height above sea level, 147 feet.

	Thickness, in feet.		Thickness, in feet.
Surface soil	7	Quartz	5
Sandy loam	2	Sand	40
Red clay	14	Light blue clay	22
Sandy clay	105	Sandy clay	22
Red and yellow clay	37	Quartz	1
		Light clay	20
Calcareous clay	29	Quartz	4
Pipe clay	5	Sand	4
Sand, clay, and lignite	49		
Sand, quartz, and pyrites	8	Total	374

Terrestrial, 9 feet; Fresh-water, 156 feet; Tertiary, (?) 209 feet.

It is difficult to understand how layers of quartz, several feet in thickness, could be interbedded with sands and clays. What is intended by "quartz" in the log is, probably, quartz gravel.

5. Alawoona Bore (see p. 174).

6. Anderson Bore (see p. 175).

7. Hundred of Bews Bore (see p. 177).

8. Cotton Bore (see p. 178).

9. Tintinara Bore (62 feet above sea level), situated about midway between Tailem Bend and Wolseley. Tate had an opportunity of examining the samples from this bore, and has summarised (Trans. Roy. Soc. S. Austr., vol. xxii., 1898, p. 67) their respective geological horizons as follows:—

	Thickness, in feet.
Recent (Terrestrial).	
Travertine, compact and rubbly	24
Newer Pleistocene (Marine).	
Sand (a few marine shells)	2
Yellow and grey sands (shells very abundant)	128
White, friable calcareous silt (apparently comminuted polyzoal debris, shells rare)	6
Black clay (with scattered shells)	84
Eocene [Miocene] (Marine).	
Blackish-brown sand (with numerous fossils)	9
Total depth	253

Tate adds: "Total thickness of the Newer Pleistocene beds is 220 feet, extending in depth from 38 feet above sea level to 182 feet below it. . . . All the determined species, as a result of comparison with authenticated specimens, are, with three exceptions, living in our seas." Mr. E. T. Clark has published a geological section of these beds ["Notes on the Geology of the Ninety-mile Desert." Trans. Roy. S. Austr., vol. xx., 1896, p. 110, pl. i.]. Mr. Chapman says: "From the great thickness of the Werrikooian shown in this bore the locality seems to be situated in an area which was sinking from at least Kalimnan times, forming a wide trough into which marine and estuarine shells were drifted." [*Loc. cit.*, p. 400.]

10. ALFRED FLAT, SALT CREEK, PETROLEUM COMPANY'S BORE. Situated about (?) six miles from the Coorong, near its southern end, and not much above sea level.

	Thickness, in feet.
Sand and quicksand	39
Quicksand with small shells	4
Gravel with green sandy clay	4
Quicksand	8
Quicksand with sea shells	2
Broken sandstone — impress of shells	3
Ironstone pebbles and sea shells	4
Quicksand with flakes of mica	3
Limestone with imprint of shells	6
Grey sandy clay	3
Sandstone pebbles with sea shells	5
Quicksand, mica, broken sea shells	22
Quicksand	4
Bed of variegated shells	40
Sea shells, darker coloured and broken	2
Very coarse dark quicksand	5
Large sandstone and ironstone pebbles	4
Dark sandy clay, full of flints, etc.	19
Rotten sandstone with flints and shells ...	30
Grey sandy clay	40
Brown shale with sandstone pebbles	5
Do., with thin layers of quartz	33
Green sandy clay—layers of black shale	43
Black quicksand, oyster shells	15
Light grey quicksand	5
Blue shale	5
Light grey quicksand	10
Light blue soapy slate	137
Dark blue shale	57
Light blue soapy slate	12
Grey sandy clay	5
Soft sandstone	3
Dark blue shale, flint, etc., pebbles	10
Sandy clay with blue and black shale	24
Very fine black slate	5
Grey sandy clay	5
Pipe clay—hard and compact	20
Black quicksand	45
Brown shale with quartz pebbles	65
Light grey pipe clay .. .	130
Brown slate	37
Red crystalline limestone	4
Total	922

[See forward, p. 189.]

7. REMARKS ON THE BORES.

GROUP I. This group of seven bores includes a series that follows in an east and west direction, about 20 miles to the southward of Loxton, situated on the northern slope of the plateau. The ground slopes to the westward and eastward as well as to the northward, the maximum heights being at *Wanbi* and *Cobera*, near the centre, reaching 252 feet above sea level. There is a general correspondence in the upper limits of the Marine Tertiary and the surface contours, the former rising and falling with the height of the ground above sea level. Fluviatile beds overlie the Tertiary in all the bores. Operations were discontinued, in each case, before the latter was proved to its complete depth.

GROUP II. The Karoonda-Peebinga railway supplies a series of bores lying between the Meribah line on the north and the Pinnaroo line on the south. Karoonda, an important junction on the line, is 223 feet above sea level, situated on the western slope of the plateau, with 89 feet of fluviatile deposits. *McNamara Bore* lies a few miles to the eastward of the former and is of about the same elevation with 88 feet of the fresh-water beds. *Anderson Bore*, about 30 miles further to the eastward, reaches the 300 feet level with 174 feet of the fluviatile series; and the *Karte Bore*, 13 miles to the eastward of Anderson and within about 14 miles of the Border, has a height of 279 feet and 170 feet of the fresh-water series. All the bores in this chain proved the existence of the Marine Tertiary, as underlying the fresh-water beds, but did not reach the base of the former.

Group III. This group of five bores differs from the rest in being parallel with the River Murray, situated lineally, to the southward of Chucka Bend. The *Semmler Bore*, the most northerly of the group, is remarkable in that its entire depth, of 374 feet, appears to consist of fresh-water deposits. The only doubtful horizon occurs at a depth of 238 feet, where a bed of sand and limestone, 18 feet in thickness, occurs; but below this horizon, as well as above it, micaceous sands and micaceous sandstones are recorded, which are typically fresh-water in their origin. The height of the bore in relation to the river and sea is not known. Its proximity to the river bed may have some significance. Although no lignite is mentioned as occurring, it is possible that the Pleistocene fresh-water series may rest directly on the sub-Miocene fresh-water series without reaching bedrock. The *Weiner Bore*, although situated to the westward of the preceding, is more distant from the river. It has an estimated thickness of 146 feet of Pleistocene alluvial, with 10 feet of boulders at the base. The Marine Tertiary, which may be absent from the Semmler Bore, is present in this bore. The *Gribble Bore* is a little more distant from the river than the two preceding bores, with the fluviatile portion reduced to 60 feet, resting on the Marine Tertiary. *Poyntz Bore*, situated about the centre of the area embraced in the Mannum curve; this, and *Chapman Bore*, to the eastward of Murray Bridge, have no Pleistocene deposits, the Marine Tertiary being at, or near, the surface.

Group IV. The four bores included in this group, like those in the Peebinga chain, to the northward, and the Bordertown chain, to the southward, are situated on the higher portions of the plateau. The *Cow Plains Bore*, close to the Border, is supposed to show 145 feet of river deposits resting on the fossiliferous Tertiary. In the *Clay Pan Bore*, 15 miles to the westward of the last-named, the fluviatile sediments may amount to anything between 160 feet and 224 feet, resting on fossiliferous limestone. The *Bews Bore*, 12 miles further to the westward, has 211 feet of the fresh-water beds, also resting on the Tertiary fossiliferous rocks; as does the *Dingo Bore*, 9 miles still further to the westward, with 162 feet of fluviatile beds.

Group V. Tailem Bend to Pinnaroo. This line of bores rises in the first 50 miles to the highest levels of the country, in the form of a flat ridge running east and west, rising to the 300-feet level at the *Cotton Bore*, and reaching a maximum height of 344 feet at Pinnaroo on the borders of Victoria. Going eastward from Tailem Bend, either Pre-Cambrian (Tailem Bend) or Marine Tertiary beds form the surface features. No Pleistocene fresh-water beds are met with till the *Geranium Bore* is reached, at a distance of 44 miles, in which they have a thickness of 73 feet. With the increasing height of the ground, going eastward, these beds thicken, till, at Pinnaroo, they are estimated to have a thickness of 222 feet. The deepest bore in this group is at Cotton, where terrestrial and fresh-water deposits were penetrated for the first 190 feet, Marine Tertiary showed a thickness of 642 feet, and Pre-Cambrian 33 feet.

Group VI. The four bores next following are situated within a few miles of the Border, having a north and south direction between the Pinnaroo and Serviceton railway lines. Their respective heights above sea level are not known, but they are probably near the 300-feet level. The *McMahon Bore* is supposed to show 197 feet of fresh-water deposits, and the *Rosy Pine Bore*, distant about three miles from the preceding, 195 feet, but the latter is somewhat indefinite from there being 78 feet of marly, sandy, and variously-coloured limestones in the upper part of the bore. This is rather thick for a surface travertine and it has been tentatively divided, the first 20 feet of marly and sandy limestone having been assigned to the travertine section, and the 58 feet of red and yellow limestone placed with the fluviatile beds that follow, making the estimated thickness of the

latter 195 feet. The fossiliferous beds follow at a depth of 215 feet. In the *Quondong Bore* no fossils are reported, but the bore finished in a limestone 72 feet in thickness, which probably represents the Marine Tertiary. The thickness of the fresh-water beds will be either 148 feet, or 218 feet, dependent on whether the freestone on the top of the limestone be placed with the fresh-water series or the Tertiary. The *Bunn Springs Bore* is about 30 miles to the northward of Bordertown. No surface travertine is recorded. The fresh-water beds consist of the usual variegated sands and sandstones with a bed of gravel, in a thickness of 118 feet, but if the yellow sandstone, that occurs above the calcareous sandstone (classed as Tertiary), should be placed with the former it would give them a greater thickness.

Group VII. Tailem Bend to Bordertown. This string of bores follow a south-easterly direction, following, in the main, the Serviceton railway line, and are situated on the southern slope of the country, towards the sea. They are all outside the range of the Pleistocene fresh-water beds. With the exception of *Tailem Bend,* where the Pre-Cambrian rocks reach the surface, and the *Tintinara* and *Alfred Flat* bores, which were sunk in Pleistocene sea deposits (see forward, p. 189), the rest of the bores, including the *Gosden Bore* (in a north-easterly direction), have the Marine Tertiary at the surface. The *Bordertown* and *Bangham Station* sections (see p. 182) are of interest as being situated nearest to the raised Pleistocene sea bed of the South-East.

Group VIII. This series of bores has been selected as following a meridional direction, from the Great Pyap Bend, on the Murray, in the north, to the Coorong, in the south. This arrangement, by intersecting the east and west ridge, shows the tectonic uplift which it is believed diverted the River Murray from its original course. The first three bores in this group *(Loxton, Angus,* and *Company's)* are closely associated on the eastern side of the Great Pyap Bend, their height above sea level being estimated from their proximity to railway stations. They all show considerable thicknesses of the fluviatile series in their upper portions. The *Company's Bore,* which is supposed to carry 128 feet of the Pleistocene fresh-water series, is remarkable for the presence of no less than 1,570 feet of Tertiary beds, 612 feet of Marine Tertiary, and 958 feet of the sub-Miocene fresh-water series, which is the thickest development of these beds known in South Australia.

It has already been stated that the river deposits which form the cliff at Loxton were traced, by means of a washout, for several hundred yards inland from the river. These can be linked on to the *Pata Bore,* near the railway station of that name, nine miles south from Loxton. The 158 feet that underlie the surface soil may, possibly, be referred to the Pleistocene fluviatile, and the remainder of the bore to the lower fresh-water lignitic series. The Pata railway station is 147 feet above sea level, or 21 feet higher than the Loxton railway station.

Alawoona, on the Meribah line, has an elevation of 231 feet, with a doubtful thickness of fresh-water beds that may be either 71 feet or 131 feet. The *Anderson Bore,* on the Peebinga line, reaches the 300 feet altitude with a fresh-water series of 174 feet. The *Hundred of Bews Bore,* at a height of 350 feet, tops the ridge with 211 feet of fresh-water beds. The *Hundred of Cotton,* on the Pinnaroo line, falls back to 300 feet, with 182 feet of fresh-water deposits. The *Tintinara Bore* is of special interest as supplying a section of marine beds of Pleistocene age. It is situated 30 miles inland from the present coast, while the nearest bores are, Coonalpyn, 16 miles to the north-west, and Emu Flat (Keith), 22 miles to the south-east, in both of which the older Tertiary marine beds are at the surface.

Chapman suggests the possibility of a rift valley, or an earth fold, by which the sea was admitted inland.

The *Alfred Flat Bore,* put down many years ago by an oil prospecting company, is probably stratigraphically connected with the Tintinara Bore, as it lies between the latter and the coast, within a few miles of the sea. I do not know that an experienced conchologist examined the organic remains of the bore, but it was reported to be in sea sand and shells, and the log (p. 186) seems to justify that conclusion. Whilst the Tintinara Bore records 220 feet of the Pleistocene Marine, the Alfred Flat Bore records 348 feet with an underlying older series of 574 feet of what is probably the Adelaide Series, bottoming on a "red crystalline limestone" that may represent the Brighton Limestone, or a member of the Purple Slates Series.

8. TECTONIC MOVEMENTS.

During some part of the Pleistocene Age an important coastal movement of elevation took place which has become distinguished as the Kosciusko Period. During this period it is believed that the great knot of highlands on the borders of New South Wales and Victoria, of which Mount Kosciusko is the most prominent height, reached their greatest elevation. This movement of uplift extended, more or less, along the southern portions of the continent, and it is to this regional uplift that we owe the southern highlands of South Australia. These positive movements in the earth's crust in the southern portions of the State were accompanied by correlative negative movements in the downward warp of the central regions. The result was the formation of a new watershed parallel to the coast which completely upset the preceding hydrographic system of the country. [See Howchin, Pres. Add. Sec. C. Aus. Assoc. Ad. Sc., vol. xiv., 1913.]

A similar movement of elevation took place on the eastern side of the Mount Lofty Ranges, as well as on the western, although of less magnitude. The section given above (fig. 5), based on borings, in a north and south direction across the Murray Plains, shows distinctly that the slopes of the plateau are not the result of erosion but of an earth-fold in which the longer axis has an east and west direction and the anticlinal slopes north and south. The following table illustrates this point:—

Name of Bore.	Height of Bore above Sea. Feet.	Height of Tertiary above Sea. Feet.	Thickness of Terrestrial Beds. Feet.	Thickness of Fresh-water Beds. Feet.
Loxton (Railway) ..	126	46	5	75
Pata	147	(?)	(?)	(?)
Alawoona	231	145	15	71
Anderson	300	125	1	174
Hundred of Bews ..	350	132	7	211
Cotton	300	110	8	182
Tintinara	62	Nil	Nil	Nil
Alfred Flat	(?) 20	Nil	Nil	Nil

The above table shows, on the line of section, that the upper portions of the plateau reach a height, between Anderson and Cotton (20 miles), of 300 feet and over. What looks like a rather sudden drop between Cotton and Tintinara can be explained by the long distance (40 miles) which separates these places, and in which distance no bores are available for comparison. The fact that the upper limits of the fossiliferous Tertiary rise with the ground and that the thickest deposits of the fresh-water beds are on the crest of the fold, in which position it is impossible for them to have been laid down, are sufficient to prove the tectonic nature of the elevation.

9. THE PHYSIOGRAPHICAL PROBLEMS.

The physiographical problems of the Lower Murray can be stated in three questions:—

1. How can the erratic course of the River Murray be explained?
2. What has led to the striking contrasts in the valley features below and above Overland Corner?
3. How can the existence of extensive fluviatile deposits to the southward of the Great Pyap Bend be explained?

With respect to the river course—it abruptly changes its direction in several instances by sharp angularities, as seen in its turn to the south at the Great Pyap Bend, with a sudden reversal to the north; its sharp turn to the west at Overland Corner, and, again, a right-angled turn to the south at the North-West Bend. This zig-zag course suggests something different in its origin from the normal development of a river as a consequent stream. The Great Pyap Bend, with its acute reversal, must have some significance, and can be fully explained by the uplift which placed an effective barrier across its previous course and directed the river into a new channel, the angularities in its course being caused by the exigency of having to follow the lowest grades available.

The tilting of the ground to the northward led to extensive flooding with back waters, until the river found its outlet at Overland Corner, from which it cut for itself a new channel in the fossiliferous Tertiary beds.

Another very remarkable feature of the Murray is its lopsidedness. Its watershed lies almost entirely to the eastward, while there is a vast country to the north and north-westward from which it receives practically no affluents. Northward of the Great Pyap Bend is an extensive area of flat, sandy country which has every appearance of an ancient river flat. The evidence obtained from borings appears to confirm this view. I am indebted to Mr. R. W. Segnit for particulars of a bore recently put down on the Morgan Vale Station (owner, Mr. G. Murray Howard), situated 66 miles due north from Loxton. The upper part of the bore revealed the presence of layers of fine sharp sand of various colours and sometimes indurated, including a 10-feet layer of clay, in all respects similar to the fresh-water series that overlies the fossiliferous Tertiary of the Murray Plains. These fluviatile beds in the Morgan Vale Bore have a thickness of 236 feet and rest on fossiliferous Tertiary beds, as in the borings to the southward. The officers of the South Australian Mines Department have also prepared sections through this northern area which shows that the bore section at the Morgan Vale Station is typical of the country generally. The country, at present, is entirely destitute of rivers and creeks.

The absence of rivers from the north and north-west quadrant of what, under normal conditions, ought to have been within the hydrographic system of the Murray, is no doubt due to the integrating control of the great central basin. If there had been no sagging of the central portions of the continent, such rivers as the Cooper and the Strzelecki would have found their outlets at the southern coast. As it is, the Strzelecki (which probably occupies the ancient bed of the Cooper), in flood times flows into a chain of lakes—Lakes Gregory, Blanche, Callabonna, and others, and these, in heavy floods, flow over into Lake Frome. This chain of lakes is on the southern margin of the great inland basin lying at the base of the great east-west geanticlinal fold that has cut off the waters coming in from the north. The Yunta-Broken Hill ridge forms a part of this earthfold which constitutes the water-parting between the Lake Eyre Basin and the southern coast. At Cockburn this ridge is only 694 feet above sea level and, with a slight-depression, would bring the rivers of the north through to the Murray. It follows, that before the Pleistocene earth movements they made this junction.

In this connection, reference may be made to a series of bores put down by the Engineer-in-Chief's Department to the north-east and east of Lake Frome, all of which showed thick deposits of alluvium consisting of variegated sands and clays, with beds of gravel and fragments of lignite, as follow, the thickness of the alluvium being given in each case, namely, Coonanna, 396 feet; Coonce Creek, 370 feet; Curraworra, 409 feet; Dewdney, 508 feet; and Arboola, 422 feet. These alluvial deposits rested on blue shale (Cretaceous).

10. THE PAST HISTORY OF THE LOWER RIVER MURRAY.

An attempt will now be made to trace the successive stages in the development of the River Murray. The Murray, or its equivalents, is an antecedent river, predating the existing physiographical outlines of the country, and is probably the most ancient river of the Australian continent.

1. The earliest stage that can be recognised in the history of the river is at a time when a transgression of the sea had submerged the Pre-Miocene terrain, reaching as far northward as the south-western portions of New South Wales. The Murray, in an abbreviated form (if it existed at all), met the sea coast in what is now a part of New South Wales, as did also the Darling as an independent river, and the Cooper in what is now South Australian territory. This may be designated the Mio-Pliocene age of the river development.

2. The second stage witnessed the gradual rise of the land in an epeirogenic uplift and, as the sea retreated southward, the northern rivers followed the retreating coastline over the plane of marine sediments left by the sea; the Murray, the Darling, and the Cooper, which had previously entered the sea as separate rivers, were now engrafted into one extended river system. The grade was low and widespread, which led to meandering streams and thick sedimentation as seen in the dead river sections both to the northward as well as southward of the present river course. Toward the coast it may have taken the form of a delta. This stage may be referred to the Early-Pleistocene age of the river development.

3. The third stage in the history of the River Murray followed on the further development of the tectonic movements which, in their initiative, had raised the Miocene marine sediments into dry land. A differential movement followed, by which a ridge was formed at right angles to the river course. The effect of this block tilting (like that on the rivers on the western side of the Mount Lofty Ranges) was to dam back the drainage, first by lowering the grade and thus causing the current to drop its load, but was too weak to enable the river to keep an open course to the seaboard. The alluviation thickened up-stream, and thereby raised the water level by which it ultimately found a new outlet to the sea. The barrier (raised at the same time) on the western side of the Mount Lofty Ranges was effective in cutting off the drainage of the central regions to the sea, while, in the case of the Murray, the elevation was insignificant and failed to close the passage to the south but forced the river into a new channel. At the same time, the sagging of the centre, by the development of the Lake Eyre Basin, altered the inclination of the country and diverted the drainage by which the northern and north-western tributaries of the Murray were captured and drawn into the centre of the depression.

Tate thought that the country above Overland Corner had, at one time, been a great lacustrine area, which, at the critical period when the change of the river's direction took place, might easily have been the case. The scores of lakes that stud this country, including such large sheets of water as Lake Bonney (or L. Barmera), a little south-eastward of Overland Corner, and Lake Victoria on

the New South Wales side of the Border, may possibly be the residuals of such a lacustrine period.

If the Murray, at an earlier stage, reached the sea by a different channel from the present, it is an interesting enquiry as to where its former mouth was situated. It seems almost certain that its outlet met the sea at a margin further inland than the present. During the Pleistocene Period the sea made encroachments on the land. Raised sea beaches occur at Victor Harbour, Hindmarsh Island, and in the banks of Salt Creek which flows into the Coorong; while the bores at Tintinara and Alfred Flat give vertical sections of the sea bed. The major part of the South-East of South Australia consists of a raised sea bed. A well-preserved sea beach of loose sand and shells rests on the flanks of the extinct volcano, Mount Graham, near Millicent, 40 feet above the normal level; and at Glencoe, 12 miles from Mount Gambier and 255 feet above the sea level. Recent shells are turned up by the plough, the larger examples, such as *Haliotis* and *Ostrea*, are collected off the land and tipped by the side of the road. Shingle beaches of rolled flints are common through the district, and can be traced from the narrow-neck drain, crossed by the Mount Gambier to Beachport railway, to as far north as Struan. Parallel ridges of dune sands occur, across country, from the seaboard to Naracoorte. This raised sea bed is probably related to a similar raised marine bed that occurs in the bends and terraces of the Glenelg River across the border, in Victoria, which is classed as Werrikooian. The presence of a sea beach on the flanks of the extinct volcano, mentioned above, is proof that this latest invasion by the sea occurred subsequently to the volcanic activity.

A feature to be noted is that the ancient fresh-water beds do not reach the present sea-board but take a south-easterly direction, marked off by the bores at Geranium, Bunn Springs, Bordertown, and Bangham (Tatiara), carrying the line to within about 20 miles of Naracoorte, where sand dunes of the Pleistocene sea coast occur; the fresh-water beds being to the eastward of this line, and the Marine Tertiary, or older beds, reach the surface on the western.

An interesting series of bores occur opposite Pinnaroo, on the Victorian side of the Border, which have been critically examined and described by Mr. F. Chapman [Rec. Geolog. Survey of Vict., vol. iii., pt. 4, 1916]. Attention was given to eleven bores situated lineally within a few miles of each other. They show a remarkable correspondence (both as to the fluviatile beds, near the surface, and the fossiliferous Tertiary Marine at depth) with those that occur on the South Australian side. The following brief references, gathered from Mr. Chapman's Report, are of interest:—

No. 1 Bore. From surface to 154 feet, sub-aerial and fluviatile sediments resting on Kalimnan [Lower Pliocene].

No. 2 Bore. From surface to 117 feet, sub-aerial and fluviatile sediments resting on Kalimnan.

Nos. 3 and 4 Bores. No material of the upper portion available for examination.

No. 5 Bore. "Sub-aerial and fluviatile deposits of Recent and Pleistocene age obtain from the surface down to 133 feet. From 133 to 155 feet we have marine and estuarine conditions prevailing, as shown by the foraminifera, probably of Newer Pleistocene. Then follows a Kalimnan deposit."—F. C.

No. 6 Bore. "The first 104 feet are composed of sub-aerial accumulations. At 104 to 114 feet there is an extremely interesting occurrence of consolidated dune-sand material with shallow-water foraminifera. From 114 to 154 feet the deposits represent the Kalimnan stage."—F. C.

No. 7 Bore. "Down to 142 feet 3 inches the deposits are chiefly sub-aerial accumulations, some of the upper 130 feet being derived from granitic rocks, as

evidenced by the quartz and mica. Below 130 feet evidence of fluviatile action is present; whilst at 142 feet the concretionary structure in the rock would seem to indicate ancient surface conditions. From 142 feet 3 inches is clearly of Kalimnan age."—F. C.

No. 8 Bore. "Down to 124 feet the beds may be regarded as probably Pleistocene, but at 124-160 feet the character of the beds changes; the fine grey, micaceous sand is equivalent to that in the previous bores with vegetable remains and estuarine foraminifera, and may represent the Upper Pliocene. True Kalimnan (Lower Pliocene) strata occur at 160-165 feet."—F. C.

No. 9 Bore. "Between this bore and the previous one some striking differences are noticed in the thickness of the superficial deposits. The usual bed of grey, micaceous, silty sand, for instance, is here represented by no less than 163 feet, as against that of 36 feet in bore No. 8. This points to a sudden deepening of the estuarine area at the present spot, caused by subsidence synchronous with deposition of silt. That the whole sedimentary series is thicker in the locality of bore No. 9 is indicated by the proportionally greater depth at which the Kalimnan beds lie under their Pleistocene cover."—F. C.

No. 10 Bore. "This bore shows a reversion to corresponding depths to those at which the Kalimnan is reached in bore No. 8; whilst bore No. 9 indicates a much greater thickness of Pleistocene deposits. At 160-186 feet the pebbly and micaceous shell-sand contains a varied fauna, indicating a shallow estuarine and marine deposit in which typical Kalimnan fossils occur."—F. C.

No. 11 Bore. "From the surface down to 148 feet the deposits are sandy and pebbly. From 148-175 feet, Upper Pliocene and Pleistocene estuarine deposits are represented by green sandy clays with brackish water and shallow marine organisms. The summit of the Kalimnan series is probably touched at 175 feet." —F. C.

In these records, carefully prepared by Mr. Chapman, there are certain marine estuarine deposits recognised that are newer than the Kalimnan, and must, therefore, be either of Newer Pliocene, or else, Pleistocene age. These shallow sea-water deposits seem to mark the inland limits of the marine transgression of the period, and were near the line of junction between the sea and the fresh-water drainage from the north. As the sea retreated, the river deposits followed in an overlap of the marine sediments, as is shown in the bores, and can be traced back to the River Murray at the Great Pyap Bend. It is probable that the lower Murray, at a former period, had a deltaic outlet and reached the sea by numerous channels spread over a wide area, reaching from the Wimmera (Vict.), in the north, to the district near Bordertown, in the south. "The sudden deepening of the estuarine area" in No. 9 Bore is strongly suggestive of a main channel in the former delta of the Murray.

11. THE PRESENT OUTLET OF THE RIVER MURRAY.

4. The fourth stage in the river's development was one of rejuvenation. Whilst the local tilt closed the old channel of outlet the regional uplift increased the grade by which the rising water found an outlet at Overland Corner, cutting for itself an incised channel in the raised Tertiary sea bed, flowing westerly, until arrested by the eastern slopes of the Mount Lofty Ranges, it turned abruptly to the south, following the contour of the country till it reached the sea. According to Tate: "At Overland Corner the gorge suddenly contracts to a width of about one mile; and as far as the North-west Bend the average width is one mile and a quarter, whilst south hence to below Blanchetown, it is three-quarters of a mile. Here and there it opens out to greater width as at Mannum, but is again contracted at its southern end" [*loc. cit.* p. 26]. Tate was probably right in stating

that the gorge was cut by a retreating waterfall. When the recession reached Overland Corner the water level was reduced and the river was able to incise its own sediments at the higher levels, as seen in the banks at Loxton, to a depth of 80 feet or more.

The Lower Murray has been under dynamic limitations arising from the low relief of the country through which it flows. It has had little scope to develop erosion features as it quickly reached base-level, and from its weak erosive efficiency has accomplished only a limited lateral development. The relatively dry conditions of the region have also, in their weak denuding effects, made slight impression on the banks, so that the cliffs in many cases are nearly, or quite, vertical and exhibit canyon features, exhibiting, although an old river, some resemblances to the juvenile stage. The gorge section of the Murray is ancient, but relatively modern when compared with the river system as a whole. It might, probably, be synchronized with the gorges cut on the western side of the Mount Lofty Ranges, as the Torrens and the Onkaparinga; the latter, in many of its features, is analogous with the River Murray.

5. This latest stage in the River Murray development covers the late Pleistocene and Recent periods. The river has completed its recession by a waterfall, it has drained the upper plateau, incised its own deposits, widening its bed between retreating escarpments, and has cut its way down to base-level. From the borders of New South Wales to the sea there is a fall of only 60 feet, and from Wentworth to the mouth of the river, a distance of 617 miles, the fall is never greater than three inches in the mile.

Within the periods under review several small alternations of level have occurred along the coastline. In the neighbourhood of Adelaide and elsewhere, there are remains of two incursions of the sea that are separated by fresh-water beds, as well as a land surface underlying the older of these two marine beds.

The local rivers, in their erosive and alluviating processes, supply an excellent index to these earth movements. At Murray Bridge, the river at low-water level is about two feet above low-water mark at Victor Harbour. But below this level there are 55 feet of water, and below the water 27 feet of silt, resting on granite, making the true bed of the river 80 feet below base-level; but as no river can erode its bed at base-level, the river bed at Murray Bridge must at one time have been, at least, 82 feet above its present level. This implies that the sea at that time was more distant than it is at present, and the river ran on a higher grade when the deeper erosion was effected. A depression of the land followed, the rivers lost grade and silted, laying down at Murray Bridge 27 feet of silt below the present water channel; at Swan Reach there are 50 feet of water and 35 feet of sediment, with a like amount of sediment at Blanchetown. A slight elevation once more took place, the sea retreated, the river, where confined to a comparatively narrow channel, made a slight erosion of its silt, and the fresh-water lakes filled the depressions vacated by the sea.

The Glenelg River, on the western borders of Victoria, supplies similar evidences as the Murray with respect to changes of level. Mr. D. Mahony, M.Sc., in a personal note to the writer, states: "The Glenelg River flows through a gorge from Limestone Creek to its mouth, and for many miles the water is 30 feet deep."

12. THE COORONG.

The Coorong was formed during this period of oscillation between land and sea. When the land rose, the sea retreated, leaving, behind it, successive ranges of sand dunes, and as the elevation increased the erosive force of the Murray also increased. The latter formed sand-bars off its mouth which contributed to

the building of the coastal sandhills. When a movement of subsidence set in the encroaching sea swept away the sandhills, the water was shallowed, and a low foreshore of great extent followed. As always happens under such circumstances, the off-sea breezes operated on the extensive sea beaches, piling up the sand as coastal dunes. This is a coastal feature from Cape Banks, in the south, to Port Elliot, in the shelter of Encounter Bay, in the north. The prevailing winds from the south-west to south-east, as well as the set of the tides, tend to produce a sand-drift to the northward. With the elevation, the strong southerly winds swept the exposed sands into a coastal ridge, but the Murray kept an open way and checked the travel of the sand to the northward, giving an unusual height and width to the sandhills of the Coorong. The coastal sandhills act as a barrier to the drainage from the land, not only in the case of superficial drainage, but the sea water, below the surface, bears up the fresh water and prevents its escape to the sea. It is thus that we have numerous swamps and lakes bordering the coast, in the South-East of the State, as well as the Coorong nearer the outlet of the Murray.

It is not improbable that the River Murray, at one time, had its mouth situated more to the southward in the direction of the Coorong. The action of the prevailing winds and tides along the coast, referred to above, tends to divert the outlets of the rivers, in a migratory movement northwards, as seen in Pedler's Creek and the Port Adelaide River, the mouth of the latter having been driven northwards by the migration of the sandhills that have formed the Lefevre's Peninsula and Port Adelaide River. In a similar manner the Coorong may, to some extent, represent a former outlet of the Murray in a more southerly position from which it has been gradually driven northwards by the encroaching sandridge. From the same cause the existing outlet of the Murray is a precarious and shifting channel. The saltness of the Coorong is not from the influx of sea-water—it is a stagnant arm of the fresh-water lakes, and its saltness is derived from evaporation and the concentration of soluble salts from the river water.

DESCRIPTION OF PLATES VI. TO VIII.

Plate VI.

Fig. 1. The River Murray at Loxton in partial flood.
Fig. 2. The River Murray at the most southerly portion of the Great Pyap Bend.

Plate VII.

Fig. 1. The River Murray below Loxton, showing the fossiliferous rock on the left bank.
Fig. 2. Silicified River Murray deposits one mile above Loxton.

Plate VIII.

Pumping Station, Loxton, on shelf excavated in river bank.
The cutting shows section of river deposits. The light-coloured bed, near the top, is a fossiliferous fresh-water limestone.

THE VOLCANIC SOIL OF MOUNT GAMBIER, SOUTH AUSTRALIA.

By J. A. Prescott and C. S. Piper,
Waite Agricultural Research Institute, University of Adelaide.

[Read July 11, 1929.]

Plate IX.

One of the most interesting soil formations in South Australia is that derived from the scoria of the extinct Pleistocene volcano of Mount Gambier.(1) The soil is remarkable for its high fertility in terms of plant nutrients and its favourable fine sandy, loamy texture, tending to a degree of looseness, locally expressed by the term "snuffiness." It is further remarkable for its association with two diseases: one of plants, the grey speck manganese deficiency of oats (Samuel and Piper, 1928),(2) and the second a disease of animals, haematuria in cattle, the cause of which is still obscure. The distribution of the soil type is limited to within a three- or four-mile radius of the town of Mount Gambier. In the north-easterly direction, where the ash beds overlie and are frequently interspersed with sand ridge country, the limits are less clearly defined than round the southern limits of the volcanic area. The precise boundaries of the type have not yet been rigidly defined, and detailed soil survey will be required before this will be possible.

From the point of view of classification within the major soil groups the type is immature and endodynamomorphic, mainly owing to the high and variable calcium carbonate content of the original parent material, so that the soil is much less acid than is the case with most South Australian soils of similar texture under similar rainfall conditions. The original native vegetation is recorded to have been mainly stringybark, *Eucalyptus obliqua;* honeysuckle, *Banksia marginata;* bracken fern, *Pteridium aquilinum;* and blackwood, *Acacia melanoxylon*. The most important crops cultivated on this soil, in order of importance, are oats, potatoes, barley, wheat and forage crops. Smaller areas are in orchard (apples principally), onions and in market garden crops. Dairy farming is of some importance.(3)

Mechanical Analysis.

Mechanical analyses are available for forty-one soils and subsoils, and as these were originally determined by the old British standard method, the results have been interpolated to the new International units and plotted in the triangular diagram illustrated in fig. 1. The soils are seen to form a definite group closely akin to that formed by the Australian tobacco soils described by E. P. Bainbridge (1928) (4). The tetrahedral representation of the mechanical analysis of the type

(1) Complete reference to the literature of the geology and physiography of the district are to be found in the paper by C. Fenner, "The Craters and Lakes of Mount Gambier, South Australia," Trans. Roy. Soc. S. Aust., vol. xlv., p. 169, 1921.

(2) G. Samuel and C. S Piper: J. Agric. S. Aust., vol. xxxi., pp. 696 and 789, 1928.

(3) For the season 1927-28 the actual acreage in crop for the combined Hundreds of Blanche and Gambier was:—Oats, 9,919; potatoes, 1,306; barley, 1,304; wheat, 792; forage, 664; orchards, 116; onions, 48; market gardens, 4. Mr. E. S. Alcock, the district agricultural instructor, estimates the acreage of crops grown on the volcanic soil to have been, in 1928, approximately:—Oats, 4,000; potatoes, 3,000 (unusually high); barley, 2,000; chou moullier, 100; wheat, 100 (rather high); lucerne, onions, mangolds, rape, each 50. Outside the volcanic area, oats is the only crop of any importance.

(4) E. P. Bainbridge, C.S.I.R. Journ., vol. i., p. 341, 1928.

is illustrated in pl. ix.(5). The distribution of the individual values about a plane within this tetrahedron is to be noted, and we are indebted to Mr. G. R. Piper

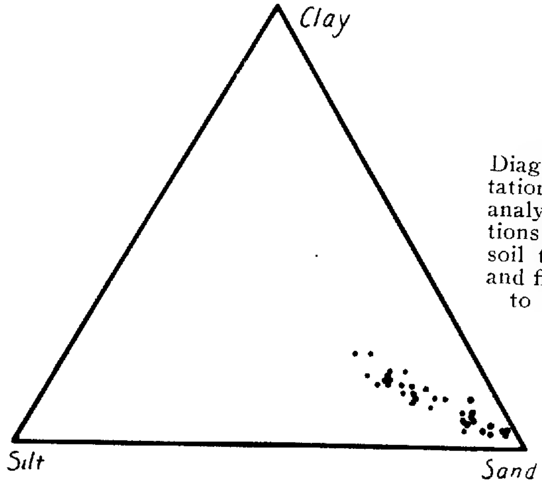


Fig. 1.
Diagrammatic representation of the mechanical analyses of mineral fractions of Mount Gambier soil types. The coarse and fine sands are united to form one group.

for a statistical examination of the data and for the calculation of the mean plane which is represented by the equation:—

$$\frac{\text{Clay}}{45\cdot3} + \frac{\text{Coarse Sand}}{92\cdot4} + \frac{\text{Fine Sand}}{103\cdot7} = 1,$$ with a standard deviation of $\pm$ 1·8 units.

when Clay + Coarse Sand + Fine Sand + Silt = 100.

The plane is determined by the intercepts:—Clay, 45; Silt, 55; Coarse Sand, 92; Silt, 8; Clay, 3; Fine Sand, 97.

The soil is noted for a high proportion of sand particles with approximately equal proportions of silt and clay. Mechanical analyses of some typical soils determined according to the official British method (1928) are given in Table 1. The average summation curve for the soil type, based on data obtained on the basis of both the old and new standards, is illustrated in fig. 2. The extremes are also indicated.

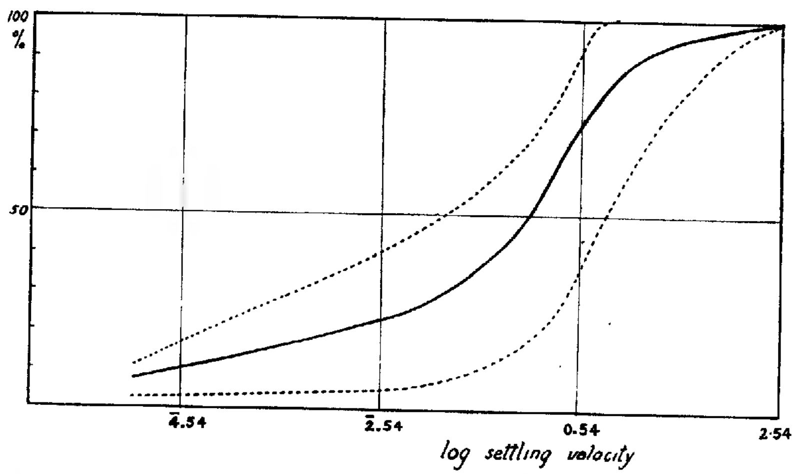


Fig. 2.
Mean summation percentage curve of mechanical analysis of Mount Gambier soils. The broken lines represent the extremes for the type.

(5) See J. A. Prescott, C.S.I.R. Journ., vol. ii., p. 112, 1929.

TABLE 1.

Mechanical Analyses of Mount Gambier Soils.

Soil No.	17	18	59	60	61	69	72	73	74	75	87	90A
Locality	x	x	G.113	Millel	G.113	B.1100	G.1287	G.1287	B.545	B.548	G.279	G.270
Depth in Inches	0-16	16-24	0-6	0-6	6-12	9-18	0-9	9-18	0-9	ash	0-9	0-6
Coarse Sand	20.7	21.4	18.0	27.8	27.5	26.0	32.3	37.5	26.1	37.6	21.7	10.1
Fine Sand	37.2	37.9	30.3	44.2	36.5	40.0	31.3	34.6	32.4	33.9	53.4	57.0
Silt	12.2	10.9	16.7	8.1	14.6	14.3	14.4	13.1	15.4	8.0	6.4	8.6
Clay	14.4	10.4	16.8	5.3	8.3	12.3	10.4	8.2	15.1	3.3	6.5	9.4
Moisture in Air-dry Soil	3.6	2.3	5.0	3.3	6.1	3.3	2.8	2.6	2.9	2.6	3.0	3.5
Calcium Carbonate	0.09	14.1	0.00	0.22	0.17	0.10	0.09	0.04	0.04	9.56	0.04	0.42
Loss on Acid Treatment	2.8	16.7	2.5	3.0	3.8	2.8	2.8	2.4	2.2	10.3	2.1	4.3
Loss on Ignition	11.7	7.8	13.8	4.5	6.1	9.6	8.7	6.7	13.0	2.5	5.1	6.7

x. Department of Agriculture's type samples for Wembley Exhibition.

B. G. refer to Hundreds of Blanche and Gambier respectively, and the number refers to the section.

Chemical Characteristics.

Reaction.

As already noted, the soils of Mount Gambier form a series which is definitely more alkaline than might be expected from the rainfall conditions. This factor is an important one in controlling the incidence of the manganese deficiency disease of oats, but is probably not the only factor. Generally speaking, however, the more acid soils are free from the disease. The frequency distribution of reaction for the type is given in Table 2.

Table 2.

Frequency Distribution of the Reaction of Mount Gambier Soils and Subsoils. Number of Samples at given pH Values.

pH.	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5
Surface Soils				2		2	1		3	1	3	2	1	3	2	3		2	2	1		1			
Subsoils					1		2		1			1	2		2	1	1			1					

The calcium carbonate content of the soil varies within wide limits from 26·7% in the ash from just inside the rim of the Blue Lake crater and 9·6% in an outcrop of ashes to negligible proportions in some of the surface soils. The more acid soils show definite lime requirements by the Hutchinson-McLennan method, but it is obviously rarely, if ever, necessary to consider the application of lime to these soils. The fact that positive lime requirement results have been obtained in the laboratory is of interest, however, from a general point of view, and a number of determinations have been made of the buffer capacities of these soils with a view to obtaining some information regarding the possibilities of

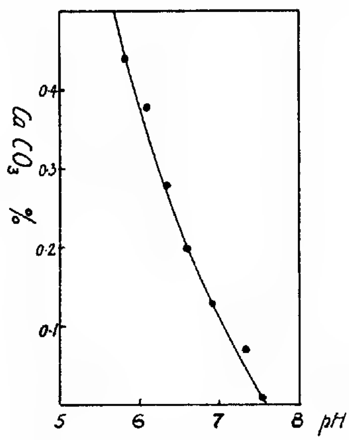


Fig. 3.

Buffer curve illustrating the effect of the addition or removal of lime (expressed as calcium carbonate) on the reaction of soil 42.

altering the soil reaction with a view to controlling the manganese deficiency disease. It will suffice to illustrate the buffer capacity of this soil over the normal range of reaction by means of the curve shown in fig. 3. This curve represents

the actual effect produced on the soil reaction by an absorption or removal of lime equivalent to the calcium carbonate indicated.

Nitrogen and Organic Matter.

The nitrogen content of a complete series of these soils is available, and the data are given in the form of a frequency distribution in Table 3. It was also found possible to work out the correlation between the nitrogen content and organic matter in a number of cases where the loss on ignition for individual soil fractions in the mechanical analysis was accurately known. The organic matter calculated from the loss on ignition after allowing for carbonates and the loss from the mineral fractions is approximately equal to the material capable of oxidation by hydrogen peroxide. A very close relationship between soil nitrogen and organic matter is obtained in this way, the percentage of nitrogen being 4·90 (see fig. 4).

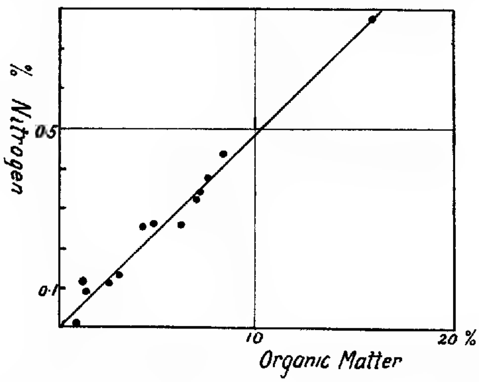


Fig. 4.

Relationship between organic matter and nitrogen content of Mount Gambier soils.

TABLE 3.

Frequency Distribution of Nitrogen percentage in Mount Gambier Soils and Subsoils.

Nitrogen %	0 .05	.05 .10	.10 .15	.15 .20	.20 .25	.25 .30	.30 .35	.35 .40	.40 .45	.45 .50	.50 .55	.55 .60	.60 .65	.65 .70	.70 .75	.75 .80
Soils		1	1	1	3	9	5	2	2							1
Subsoils	2	3	4	2												

TABLE 4.

Exchangeable Bases in Mount Gambier Soils.

Soil No.	pH	Mg. equivalents per 100 gm. of Soil.					Relative percentage proportions of Bases.				Remarks.
		Ca	Mg	K	Na	Total	Ca	Mg	K	Na	
17	6.9	21.6	5.6	1.2	2.8	31.2	69	18	4	9	Type sample
58	7.9	27.4	3.1	1.2	2.9	34.6	79	9	4	8	Diseased oats
59	6.4	17.2	3.4	1.6	2.5	24.7	70	14	6	10	Healthy oats
68	7.8	24.2	3.0	1.8	2.8	31.8	76	9	6	9	Type sample
72	7.4	20.8	2.5	1.6	2.6	27.5	76	9	6	9	Type sample
73	7.3	12.5	2.6	1.2	3.0	19.3	65	13	6	16	Subsoil of 72
90A	7.6	21.8	2.6	1.1	3.6	29.1	75	9	4	12	Diseased oats

TABLE 5.

Chemical Analyses of Typical Mount Gambier Soils. Hydrochloric Acid Extract.

Soil No.		17	18	58	59	68	69	71	72	73	74	75	90
Iron Oxide	Fe_2O_3 %	5.16	4.43	6.21	6.11	5.33	6.27	3.80	5.46	5.84	5.27	8.76	2.36
Alumina	Al_2O_3 %	5.46	5.27	5.85	5.60	6.12	7.36	3.03	4.84	6.09	5.76	9.41	2.77
Lime	CaO %	1.42	8.53	2.65	1.09	4.12	1.56	15.30	1.95	1.64	1.53	9.84	0.88
Magnesia	MgO %	1.84	2.38	2.04	1.59	2.09	2.39	2.71	2.59	3.12	1.98	5.78	0.71
Potash	K_2O %	0.32	0.27	0.28	0.30	0.35	0.39	0.35	0.29	0.27	0.32	1.67	0.08
Oxide of Manganese ...	Mn_3O_4 %	0.043	0.043	0.068	0.059	0.068	0.056	0.025	0.064	0.055	0.052	0.09	0.036
Phosphoric Acid	P_2O_5 %	0.24	0.15	0.51	0.42	0.32	0.33	0.15	0.39	0.16	0.27	0.33	0.20
Titanic Oxide	TiO_2 %	0.65	0.57	0.88	0.72	0.67	0.84	0.32	0.74	0.86	0.71	1.26	0.48
Nitrogen	N %	0.34	0.11	0.41	0.44	0.31	0.12	0.26	0.26	0.09	0.25	0.01	0.26
Reaction	pH %	6.9	8.0	7.9	6.4	7.8	7.7	8.0	7.4	7.3	7.5	7.6	7.2
Calcium Carbonate		0.09	14.10	1.16	Nil	3.96	0.10	26.68	0.09	0.04	0.04	9.56	0.04

REMARKS:

17. Type sample, Wembley Exhibition, 0-16".
18. Subsoil of 17, 16-24".
58. Hd. Gambier. Sn. 113. Diseased oats. 0-6".
59. Hd. Gambier. Sn. 113. Healthy oats. 0-6".
68. Hd. Blanche. Sn. 1100. 0-9".
69. Subsoil of 68. 9-18".
71. Volcanic ash inside rim of Blue Lake.
72. Hd. Gambier. Sn. 1287. 0-9".
73. Subsoil of 72.
74. Hd. Blanche. Sn. 545. 0-9".
75. Outcrop of Ashes. Hd. Blanche. Sn. 548.
90. Hd. Gambier. Sn. 270. 0-9". Diseased oats.

Exchangeable Bases.

The Mount Gambier soil presents no special features in this connection except a highly satisfactory proportionate distribution of the four significant bases. Soils containing significant quantities (0·1%) of calcium carbonate have reaction values between pH 7·5 and 8·0, so that it is likely that these soils may be considered to be fully saturated when in equilibrium at these reaction values. So far no attempt has been made to determine the degree of saturation of the soil with replaceable bases.

The values for the type sample, No. 68, are recorded diagrammatically in fig. 5.

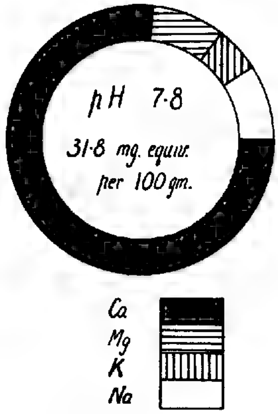


Fig. 5.

Exchangeable bases in type sample No. 68.

Hydrochloric Acid Extract.

A number of typical soils, including two samples of unweathered ash, were extracted with hydrochloric acid by the conventional method for plant nutrients. Both ash samples Nos. 71 and 75 are notable for their high content in calcium carbonate. The most notable feature from the plant nutrition point of view is the content of phosphoric acid which is remarkably high for South Australia, the proportion being of the same order of magnitude as for the basaltic soils of Eastern Australia.

The amount of potash and phosphoric acid soluble in one per cent. citric acid determined in a single typical surface soil (No. 74) indicated a high availability for both nutrients, 0·024% K_2O and 0·036% P_2O_5. The results of the chemical analyses are recorded in Table 5.

DESCRIPTION OF PLATE IX.

Tetrahedral representation of mechanical analyses of Mount Gambier soils.

NOTES ON SOME MISCELLANEOUS COLEOPTERA, WITH DESCRIPTIONS ON NEW SPECIES.

PART VII.

By Arthur M. Lea, F.E.S.
(Contribution from the South Australian Museum.)

[Read August 8, 1929.]

STAPHYLINIDAE.

Diochus pubiventris, n. sp.

Black, prothorax, muzzle, antennae (some of the median joints infuscated), palpi, tips of elytra, and of abdominal segments, and the legs more or less reddish, or reddish-flavous. Sides with a few bristles, the abdomen with fine ashen pubescence.

Head rather long, with a few distinct punctures. Antennae rather long, seventh-tenth joints transverse. Prothorax slightly longer than wide, base evenly rounded and slightly wider than apex, sides gently rounded; with a few marginal punctures, and three forming a row on each side of middle. Elytra subquadrate, a narrow impression on each side of suture; with sparse and usually indistinct punctures. Abdomen long, parallel-sided to near apex; with dense, minute punctures. Length, 3·5-4·0 mm.

North Australia: Darwin (N. Davies, G. F. Hill, and British Museum); New South Wales: Tamworth (A. M. Lea). Type, I. 15889.

The suture is usually obscurely paler than the adjacent parts, but only the extreme tips of the elytra are noticeably pale; on *D. divisus* fully half or more of the elytra is pale. The pronotum is usually of a dingy castaneous-red, but sometimes the front parts are obscurely infuscated. From most directions the elytra appear polished and impunctate, but from others a few feeble rugose punctures may be seen.

Diochus longus, n. sp.

Black, shining, apical two-fifths of elytra, tips of abdominal segments, muzzle, palpi and legs more or less reddish-flavous. Abdomen with fine, ashen pubescence, sides with a few bristles.

Head distinctly longer than wide, a few distinct punctures in middle, becoming rather numerous on sides. Antennae short, fourth-tenth joints transverse. Prothorax distinctly longer than wide, base and apex rounded, sides parallel; with a few distinct submarginal punctures, and three forming a row on each side of middle. Elytra slightly longer than wide, surface faintly rugose but with some small punctures towards sides; suture feebly elevated. Abdomen with dense and minute punctures. Length, 4 mm.

Western Australia: Bunbury (A. M. Lea); unique.

The antennae are decidedly shorter than on *D. divisus* and *octavii*, most of the joints being transverse; they are infuscated throughout, although the apical joint is slightly paler than the preceding ones.

Neobisnius mediopolitus, n. sp.

♀. Black, basal joints of antennae, palpi and tarsi reddish, rest of legs, tip of abdomen, and suture and tips of elytra obscurely diluted with red. Elytra and abdomen with fairly dense, ashen pubescence, prothorax and head sparsely clothed.

Head subquadrate between clypeus and neck; with dense and sharply defined punctures, except on a median line that is dilated in front. Antennae rather short, fourth and fifth joints slightly, the sixth-tenth strongly transverse. Prothorax longer than wide, sides feebly decreasing in width posteriorly; punctures as on head, and also leaving a shining median line. Elytra distinctly longer than wide, sides parallel, suture finely carinated; punctures smaller and more crowded than on prothorax. Abdomen with five basal segments almost parallel-sided, with smaller and slightly denser punctures than on elytra; anal styles long. Length, 5 mm.

Victoria: Melbourne (F. Fischer). Type, I. 15890.

Near *N. procerulus,* but larger, elytra with smaller and denser punctures, and their tips not conspicuously pale; on *procerulus,* although only a small portion of the tips is pale, that portion is quite distinct; on the present species it is even smaller and needs looking for.

Philonthus inconspicuus, n. sp.

Piceous-brown, legs, palpi and basal joints of antennae paler. A few setae scattered about, the abdomen with short, ashen pubescence.

Head quadrate between clypeus and neck; a shallow triangular impression in front; with a few punctures. Eyes rather small. Antennae rather short, fourth to tenth joints transverse. Apical joint of palpi thin and rather long. Prothorax longer than wide, with straight sides, feebly diminishing in width posteriorly; with sparse, distinct, submarginal punctures, and four forming a series on each side of middle. Elytra slightly longer than wide, sides almost parallel, a narrowly impressed line on each side of suture, and one on each side; with fairly dense, sharply defined punctures, almost as large as those on pronotum. Abdomen parallel-sided to near apex, punctures smaller and denser than on elytra, and smaller on back parts of segments. Length, 3·2-3·5 mm.

Queensland: Coen River (W. D. Dodd), Mulgrave River (H. Hacker). Type, I. 12705.

Decidedly smaller than any *Philonthus* previously recorded from Australia, but the species certainly appears to belong to the same genus as *P. nigritulus,* of which the specimens have the appearance as of pale ones on a greatly reduced scale. The apical joint of the palpi is thinner than usual, but scarcely bristle-like, as on *Heterothops.* The prothorax is slightly paler than the head, and the base and apex of the abdomen are paler than the middle, but the colours are dingy, although most of the upper surface is polished.

Cafius gigas, n. sp.

♂: Black, in parts with a faint metallic gloss; antennae, palpi, legs and tips of abdominal segments, more or less reddish-brown. Elytra and abdomen with depressed, blackish pubescence or setae, the sides with a few bristles, becoming dense on tip of abdomen; some mouth parts with very dense, flavous pubescence.

Head large, slightly transverse between clypeus and neck; with large and small, irregularly distributed punctures, more crowded about hind angles than elsewhere. Antennae moderately long, first joint as long as second and third combined, and much longer than eyes, ninth and tenth feebly transverse. Apical joint of palpi very little longer than subapical. Prothorax about as long as the apical width, sides gently decreasing in width to base, which is gently rounded; with large and small, irregularly distributed punctures, but leaving an ill-defined median line. Elytra slightly wider than prothorax, and not much longer, outer apical angles obliquely cut off; punctures crowded and rugose, but not very large. Abdomen with sides evenly decreasing in width posteriorly; punctures more elongated and less crowded than on elytra; tip of under surface deeply notched. Tibiae with numerous spines and bristles; front tarsi dilated. Length, 19-20 mm.

♀. Differs in having the head considerably smaller, elytra narrower, abdomen not notched, and front tarsi less dilated.

Lord Howe Island: Mount Ledgbird. Types, in Australian Museum.

The hairy mouth parts, mandibles, palpi, sides of prothorax, legs and generic details generally are as in *Cafius;* but the species is considerably longer and wider than any other of that genus before me, and the types were not taken from sea-beaches, where those of the genus are usually to be found. The mandibles are stout, with a strong tooth about the middle, on the left one of the male (those of the female are concealed) there are some minute granules on the anterior edge of the tooth; the large punctures on the pronotum are fairly dense on the sides and near the median line. The types were known to Olliff, but were passed over by him.

HETEROTHOPS SEMICUPREA, Fvl.

Mr. Arrow kindly sent a cotype of this species for examination. In general appearance it is close to *H. kentiae,* but differs in being more robust, head distinctly longer and more oval, elytra with larger punctures, suture scarcely elevated, and the dark blotch slightly more distant from suture. It is closer to *H. bimaculata,* the outlines being practically identical, but the spot on each elytron is somewhat differently placed, and more of the abdomen is pale.

Heterothops myrmeciae, n. sp.

Black, shining, elytra blackish-brown, the tips obscurely pale, apical segment of abdomen, tips of most of the others, mouth parts, palpi, four basal joints of antennae, and the legs, brownish-flavous. Elytra and abdomen with short, depressed, pale pubescence, the sides with a few setae.

Head subovate, more convex than usual, with very few scattered punctures. Eyes small. Antennae rather long, first joint almost as long as second and third combined, sixth-seventh feebly, eighth-tenth moderately transverse. Apical joint of palpi setiform, almost as long as the subapical one. Prothorax transverse, base strongly rounded and much wider than apex; with a few marginal punctures, and two in middle, about one-fourth from apex. Elytra subquadrate, suture feebly elevated posteriorly; with dense and small punctures. Abdomen almost parallel-sided to near apex, punctures mostly less distinct than on elytra; anal styles long. Length, 3·5-4·0 mm.

Victoria: Northern Gippsland (H. W. Davey), Fern Tree Gully, in July (C. Oke). Type, I. 15894.

With the general appearance of *H. luctuosa,* but the eyes are much smaller, the abdomen is less iridescent, and more of it is pale; it is decidedly wider than *H. picipennis,* but the eyes are much the same; it is less robust than *H. obscuripennis,* and has much smaller eyes. On one specimen there is a small puncture immediately behind each of the two distinct ones on the pronotum. One of the specimens was taken by Mr. Oke from a nest of a black "jumper" ant *(Myrmecia pilosula).*

Quedius macrops, n. sp.

♂. Black, shining, antennae, palpi, legs and tips of several abdominal segments more or less reddish. Elytra with fairly dense, depressed, dark pubescence, somewhat longer and sparser on abdomen; sides with blackish bristles, becoming dense on abdomen.

Head moderately large; with a few conspicuous punctures near eyes and neck, a shallow depression near each antenna. Eyes very large, occupying most of the sides between clypeus and neck. Antennae rather thin, eighth-tenth joints each about as long as wide. Prothorax slightly transverse, base strongly rounded and wider than apex; with a few marginal punctures, and two submedian ones. Elytra distinctly wider than long, suture moderately elevated; punctures rather

dense and small. Abdomen regularly diminishing in width posteriorly, punctures about bases of segments larger than on elytra, becoming smaller and sparser posteriorly; tip of under surface with a small triangular notch. Front tarsi moderately inflated, middle pair combless. Length, 5·0-5·5 mm.

♀. Differs in having the head slightly smaller, antennae slightly shorter, front tarsi not inflated, and abdomen not notched at apex.

Queensland: Herberton (H. J. Carter); New South Wales: Sydney (R. Helms). Type, I. 15891.

About the size of *Q. tepperi* and *cuprinus*, but head of different shape, with much larger eyes, antennae paler, etc.; the eyes are larger than on *Q. hackeri*, the legs are somewhat darker, and the middle tarsi are combless; *Q. luridipennis* has somewhat smaller eyes and combed middle tarsi in the male. Both surfaces of the abdomen are brilliantly iridescent, as are also parts of the legs. The elytra are not as black as the other parts, and their extreme tips are obscurely diluted with red on five specimens; on a sixth the elytra are obscurely reddish, in parts deeply infuscated. In some lights the head and prothorax have a silken gloss.

Quedius calogaster, n. sp.

♂. Black, shining; antennae, palpi, most of legs, apical segment of abdomen and apex of subapical one, more or less red, elytra with a slight greenish gloss, the shoulders, sides, and tips obscurely diluted with red. Elytra with moderately dense, dark pubescence, becoming sparser and longer on abdomen; sides with sparse, long, blackish bristles, becoming rather dense on abdomen.

Head rather large, with a few strong punctures near eyes and neck. Eyes large. Antennae moderately long, sixth-tenth joints feebly transverse. Prothorax moderately transverse, base strongly and evenly rounded; with a few large marginal punctures, and two close together one-third from apex. Elytra slightly transverse, each separately rounded at apex; with dense and small punctures. Abdomen regularly diminishing in width posteriorly; punctures about as large as on elytra, at bases of segments, but sparser and smaller posteriorly; tip of under surface slightly notched; anal styles long. Front tarsi moderately inflated. Length, 6-7 mm.

♀. Differs in having the head smaller, antennae somewhat shorter, elytra smaller and entirely dark, abdomen not notched, and front tarsi not dilated.

Queensland: Ravenshoe and Magnetic Island (H. J. Carter). Type, I. 15892.

In general appearance close to *Q. iridiventris* and *inconspicuus*, but head of different shape, with larger eyes, and paler antennae. Both surfaces of the abdomen are brilliantly iridescent, the colours varying with the light from almost entirely purplish-blue to almost entirely coppery. From some directions the elytra appear to be minutely granulate. Under the microscope I could not see a comb on the middle tarsi of the male, but a leg was not detached from the type for special examination.

Quedius insignis, n. sp.

♂. Black, shining; elytra pale castaneous, four basal joints of antennae, parts of palpi, and the tarsi, more or less obscurely reddish. Abdomen sparsely setose and with fairly numerous bristles.

Head rather small, with minute, scattered punctures. Eyes not very large, about as long as the inter-antennary space. Antennae short and stout, first joint almost as long as second and third combined, third distinctly longer than second and the length of eleventh, fourth moderately, the fifth-tenth strongly transverse. Palpi short, subapical joint obtriangular and slightly longer than apical. Mandibles short and strong. Prothorax moderately transverse, base and sides evenly rounded; a very finely impressed line on all margins, on each side it bifurcates at about the apical third, so that a narrow triangle is enclosed at the apex; with a few distinct

punctures. Elytra subquadrate, sides gently rounded, apex truncated; with a narrowly impressed line on each side of suture, and one before each inflexed margin; with a few distinct punctures. Abdomen slightly inflated about middle, with distinct but irregularly distributed punctures; apex of under surface with a deep notch. Legs short, front tarsi moderately dilated. Length, 7 mm.

Victoria: Beaconsfield (F. E. Wilson). Type (unique), I. 15893.

With the general appearance of the European *Astrapaeus ulmi*, on a greatly reduced scale, but the type is certainly a male, and its palpi have the apical joint small and wedge-shaped, instead of large and securiform. For the present it may be referred to *Quedius*, although the punctures and antennae are very unlike those of all other described Australian species. The eighth-tenth joints of antennae are fully twice as wide as long. There are a few upright setae on the elytra near the suture, and a few submarginal ones, the elytra otherwise being glabrous. There is a distinct row of punctures on each side of the suture, and another about the middle of each elytron, about the tips there are a few punctures, and short impressed lines. There are a few distinct submarginal punctures on the pronotum, including two median ones almost at the apex, instead of some distance from it, as on other species of *Quedius*.

Acylophorus tenuipes, n. sp.

♀. Blackish-brown, antennae (some of the median joints slightly infuscated), palpi, tarsi, and tips of two apical segments of abdomen paler. Elytra and abdomen with dark, depressed pubescence or setae, the sides with a few bristles.

Head rather convex, between clypeus and neck as long as wide, with numerous small punctures and six large ones. Mandibles thin and acute, each with a rounded projection towards base. Antennae rather long and thin, first joint curved, as long as three following combined, and about twice the length of eyes, second as long as third and fourth combined, the others gradually decreasing in length, ninth and tenth somewhat transverse. Prothorax slightly transverse, apex scarcely as wide as base, which is evenly rounded, sides finely rounded; with numerous minute punctures, and a few large ones. Elytra not much longer or wider than prothorax, with dense and somewhat rugose punctures, of moderate size or rather small. Abdomen almost parallel-sided to near apex, punctures slightly larger and more angular than on elytra. Tarsi thin. Length, 7·5-8·5 mm.

Queensland: Brisbane, in July (H. Hacker). Type, in Queensland Museum; cotype, in South Australian Museum.

It is with some doubts that this species is referred to *Acylophorus*, as the head is much larger than on the other species known to me *(A. glaberrimus, ruficollis* and *asperatus)*; but in the allied genera *Quedius (e.g., Q. analis* and *fulgidus)* and *Heterothops (e.g., H. tibialis* and *laticeps)* the heads differ greatly in size. I have considered the possibility of the species belonging to *Quediopsis* (the three specimens are strikingly like many species of *Quedius*, to which, if shorn of their antennae, they would almost certainly be referred), but Fauvel states that the antennae of that genus are not so strongly geniculate as in *Acylophorus*; he also states that in the male the three basal joints of the tarsi are *"maxime dilatatis, patellatis,"* so that those of the female are at least likely to be of considerable width instead of thin; the maxillary palpi were described as having the three apical joints equal, in this species the subapical joint is shorter than the preceding or following ones; the antennae were noted as having all the joints longer than wide, in this species two are certainly transverse.

Only the type appears to be mature, two other specimens are pale castaneous, with most of the abdomen infuscated; all, however, have some of the median joints of the antennae infuscated; all have the anal styles withdrawn, but their outlines are visible through the derm. Of the large punctures on the head, two are rather

close together between the eyes, and four are subbasal in oblique pairs, on the pronotum two are submedian as on most species of *Quedius,* and there are two or three near the front angles.

Atanygnathus bicolor, n. sp.

Black, shining, basal three-fifths of prothorax, apex of elytra, palpi, and legs flavous, or flavous-brown, antennae with basal and apical joints pale, the others more or less deeply infuscated. Elytra and abdomen with fine, depressed, pale pubescence; the sides, especially of abdomen, with dark bristles.

Head elongate, polished and impunctate. Antennae long and thin, no joint transverse. Prothorax transverse, sides moderately rounded, the base more strongly so, front angles rounded off, with a few small punctures scattered about, and a distinct one on each side of the middle. Elytra subquadrate, outer apical angles notched, with small, evenly crowded punctures. Abdomen evenly diminishing in width posteriorly, with punctures as on elytra, except that there are some larger ones at the tips of four segments; anal styles long. Length, 3-4 mm.

North Australia: Daly River (H. Wesselman), Oenpelli (National Museum from P. Cahill), Darwin (G. F. Hill), Adelaide River (British Museum), Melville Island (W. D. Dodd). Type, I. 12762.

The bicoloured prothorax and elytra are at once distinctive from *A. terminalis.* Usually only one basal joint of antennae is pale, but there are four or five (sometimes almost white) at the apex, the dark part of the pronotum is usually quite black, but occasionally is dark brown; the abdomen is slightly iridescent and the tips of the segments obscurely diluted with red.

CUCUJIDAE.

Laemophlaeus distorticornis, n. sp.

♂. Dark brown and opaque, muzzle and elytra, except for markings, paler.

Head somewhat flattened, with a narrow, shining, median line; very minutely punctate. Antennae very long and thin, first joint distorted, the others cylindrical, third slightly longer than second or fourth, but shorter than fifth, fifth-tenth equal, the eleventh slightly longer. Prothorax with sides gently rounded and distinctly wider at apex than at base, a narrow carina near each side, but not quite parallel

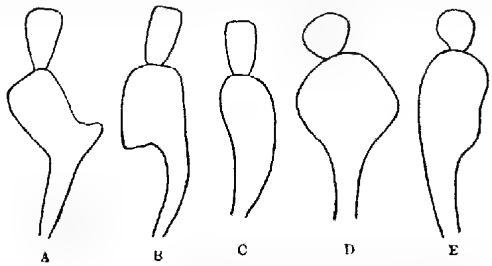


Fig. 1.
A, B, C, Two basal joints of antennae of *Laemophlaeus distorticornis* Lea; D, E, of *L. norfolcensis* Lea.

with it; punctures as on head. Elytra with a fairly well defined subsutural stria, and with three geminate pairs of striae on each elytron, the interstice between each pair feebly raised but posteriorly becoming subcarinated. Length, 1·5-2·0 mm.

♀. Differs in having the head smaller, antennae shorter, with the first joint not distorted, but evenly dilated to apex, and the prothorax less conspicuously dilated to apex.

Lord Howe Island (A. M. Lea). Type, I. 7591.

At first glance apparently close to *L. blackburni*, but elytral markings different, antennae very much longer and thinner, and first joint very different. The elytra are of a dingy flavous, with a conspicuous brown fascia in the middle, extending from the suture to the first pair of discal geminate striae, along these it is directed for a short distance towards the base, and posteriorly towards the apex, but half-way to the latter it is suddenly directed outwards but not to the margins, on some specimens the markings are somewhat like an M; on some the markings consist of disconnected spots; on others there is an infuscation of the suture posteriorly in addition to the M-like markings; each joint of the antennae is paler at the base than at the apex. The antennae are unusually long and thin, being quite as long as the body on the female, and conspicuously longer on the male; the first joint of the male varies considerably; on some specimens, including the type, it is evenly dilated from the base to the middle and is then suddenly thickened and deflected, but it varies in appearance (fig. 1, A and B) from almost every point of view; on other specimens (fig. 1, C) it is considerably smaller and curved, rather than distorted. Seventeen specimens were obtained.

Laemophlaeus howensis, n. sp.

♂. Pale flavo-castaneous and moderately shining.

Head flat between eyes but gently semi-circularly concave in front, median line slightly impressed but distinct; punctures dense and small but rather sharply defined. Antennae extending to hind coxae, first joint long, stout, and strongly curved, second globular and slightly larger than third, fourth-tenth subequal, eleventh slightly longer. Prothorax about once and one-half as wide as long, apex scarcely wider than base, sides very feebly rounded, with a narrow carina towards each side but scarcely parallel with it; punctures as on head. Elytra with sub-sutural and geminate striae much as on preceding species. Length, 1·2-1·7 mm.

♀. Differs in having the head somewhat smaller, and antennae shorter, with the first joint smaller and scarcely curved.

Lord Howe Island (A. M. Lea). Type, I. 7592.

Allied to *L. diemenensis*, but smaller, less polished, basal joint of antennae of male very different and the following ones very similar to those of the female, the elytral striation is also much less defined; it is much the size and colours of *L. testaceus* but is much less polished and is otherwise very different. A specimen of each sex was taken.

Var. (?). A female from the island is structurally so close to the female of this species, that it appears desirable to leave it unnamed till a male can be obtained; it differs from the female in being smaller, and with the whole of the upper surface opaque.

Laemophlaeus bimaculiflavus, n. sp.

Castaneous and shining, prothorax somewhat darker, elytra still darker, almost black, but with two large, sharply defined, flavous spots.

Head wide, with a feeble median line, a sharply impressed line near base and another near each eye (these large), with a shallow depression towards each side; punctures small and dense but sharply defined. Antennae not much longer than head and prothorax combined, first joint stout, not as long as second and third combined, second subglobular, third moderately long, fourth-eighth sub-elliptic and subequal, ninth and tenth slightly longer, increasing in width to apex, eleventh ovate. Prothorax almost twice as wide as long, sides rounded, base much narrower than apex, with the hind angles acute and slightly produced, a well impressed stria towards each side, rather suddenly deepened near base; punctures slightly sparser, but otherwise as on head. Elytra wide, sides gently rounded; subsutural stria on each distinct only posteriorly, inwards of each

shoulder with two conjoined striae, the inner one rather deep, oblique and terminated near apex, the other vanishing before the middle, a sharply impressed stria commencing on the margin at the base, and slightly diverging from the margin till it suddenly terminates near the apex; punctures much as on prothorax. Length, 5 mm.

Lord Howe Island (A. M. Lea). Type, I. 7594.

A well-marked species, larger than any other known from Australia. The flavous spot on each elytron is about the length of the prothorax, and half the width; it commences at about the basal fifth and is fairly close to the suture and outer margin.

Laemophlaeus fuscolineatus, n. sp.

Castaneous, elytra with suture and three narrow lines on each infuscated. Very finely pubescent.

Head rather flat between eyes, with a feeble depression towards each side, median line slightly impressed; punctures small and dense. Antennae moderately long, first joint stout, second-eighth subglobular and rather small, ninth-eleventh somewhat longer and forming a loose club. Prothorax strongly transverse, sides slightly rounded and very little wider at apex than at base, with a narrow carina towards and almost parallel with each side; a shining and almost impunctate median line, but elsewhere punctures much as on head. Elytra with a subsutural and three geminate striae on each; punctures smaller and denser than on head. Length, 2 mm.

Lord Howe Island (A. M. Lea). Type, I. 7595.

A very distinct species. From some directions the pronotum appears to have two vaguely infuscated vittae; the elytral markings consist of seven sharply defined, infuscated lines, extending from the base to near the apex, they are all narrow, but the sutural marking is twice the width of each of the others; the striae themselves are much as on *L. distorticornis* and *howensis*.

Laemophlaeus norfolcensis, n. sp.

♂. Pale castaneous and somewhat shining.

Head large, somewhat concave in front, median line well defined; with small, dense punctures, and very finely shagreened. Antennae rather long, first joint long, suddenly and strongly dilated from about the middle, second and third subglobular and subequal, fourth-eighth subequal in length but gradually becoming thinner, ninth-eleventh longer and highly polished. Prothorax at apex almost twice the median length, sides feebly diminishing in width from apex to base, a fine carina towards and almost parallel with each side; with a shining and impunctate median line; punctures and shagreening as on head. Elytra rather wide, striae well defined and scarcely geminate in arrangement. Length, 2·5 mm.

Norfolk Island (A. M. Lea). Type (unique), I. 7593.

Allied to *L. diemenensis*, but prothorax much wider and antennae very different; as the basal joint of the antennae varies considerably in appearance with the point of view, two outlines of it (fig. 1, D and E) have been given. The head and prothorax have a somewhat silken appearance, the elytra are slightly darker and more polished, but with the middle somewhat diluted in colour. There is a fringe of very fine setae on the front margin of the prothorax.

LUCANIDAE.

Ceratogathus minutus, n. sp.

♂. Blackish, mesosternum, metasternum and abdomen almost flavous, legs and antennae darker, basal joints of antennae paler than lamellae. Moderately clothed with short dark setae, mixed with white ones, more or less condensed to form feeble spots.

Head transverse; with crowded punctures, a small process on each side partly concealed by base of antennae. Mandibles rather short. Basal joint of antennae curved, about as long as the five following combined, of these the first is almost globular and the others are small; club composed of three elongate lamellae. Prothorax almost twice as wide as long, sides rounded and minutely serrate, apex

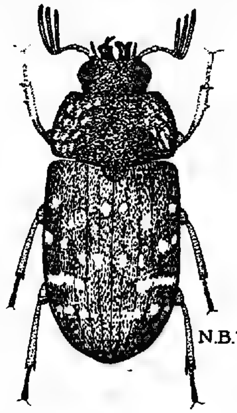


Fig. 2.
Ceratognathus minutus Lea.

shallowly emarginate, base bisinuate; punctures much as on head. Elytra parallel-sided to near apex; finely striated and with crowded punctures. Legs thin, claw-joints elongate. Length, 4·5 mm.

New South Wales: National Park (N. B. Tindale). Type (unique), I. 16956.

The type is the smallest stag-beetle that I have seen from any part of the world; its length is less than that of the elytra of *C. niger*, and its mandibles are about the length of those of the female of that species, although by its antennae the type is evidently a male. The mandibles are distinctly shorter than the head, the left one has three cusps: an obtuse outer one, an acute one curved to the right, inwards of which is a smaller acute one; the right mandible has but two cusps, and from some directions appears as a short, broad Y. Each of the middle tibiae has a small medio-external tooth, becoming still smaller on the hind ones; parts of both front legs are missing.

LAMPRIMA ADOLPHINAE Gestro (*Neolamprima*).

Of three males under examination one specimen measures 49 mm., with mandibles 15 mm., and is a typical *Neolamprima*. It is mostly of a dark greenish-purple with the head brassy. A second specimen measures 36 mm., with the

Fig. 3.
Lamprima adolphinae Gestro, natural size.

mandibles 11 mm.; it is also a typical *Neolamprima*, although the mandibles are somewhat shorter and with less numerous teeth. It is of an uniform coppery colour, except that the prothorax is subopaque, in contrast with the shining head and elytra. The third specimen measures 25 mm., with the mandibles 6 mm., and appears quite a normal *Lamprima*. It is of a dull bronze colour, with the head polished and partly coppery-purple. All three have the pronotum rather coarsely shagreened, and the elytra more finely so and with vermiculate scratches. The first specimen was from an unknown locality in New Guinea, the others are from Komba (at an elevation of 5,000 feet), from the Rev. L. Wagner, who also sent two females; of these one is entirely coppery-golden on the upper surface, the second has the elytra deep blue, shading off to coppery-green at the suture, its pronotum is deep purple and head coppery. Both specimens are, in fact, very similar to Queensland females of *L. mandibularis*.

SCARABAEIDAE.

Diaphonia gulosa Jans., var **angustiflava,** n. var.

Two males in the Australian Museum, from Mount Warning (on the northern border of New South Wales), taken in January by Mr. A. Musgrave, evidently represent a variety of *D. gulosa*. In structure they agree perfectly with normal Victorian males of the species. One specimen has the dark parts almost or quite black, with flavous markings consisting of two spots on the head in front of the eyes, the pronotum with a narrow medioapical fascia, a vitta on each side from apex almost to base, but with a median dark spot; the scutellum with a short, narrow, median spot, each elytron with a narrow vitta from the middle of its base to the apical fifth, where it curves round (like a small hook) to near the suture, a thinner marginal vitta from the base to the basal third, and a narrow apical fascia; on the under parts there is a small spot on each side of the mesosternum and metasternum, the side of each hind coxa and on each side of four basal segments of abdomen, four disconnected spots on the pygidium; the intercoxal process of the mesosternum; and there is also a spot on each hind femur. On the second specimen the pale spots on the head are extended and almost conjoined, the apical and lateral marks on the pronotum are joined together, and there are three small spots triangularly placed between the middle and the base, the scutellum is largely pale, the dark parts of the elytra are paler (dark purplish-brown), the long flavous vitta on each is almost the same, but the latero-basal one is wider, slightly longer, and there is an obscure spot between it and the transverse apical mark; the markings on the under surface and legs are more extended and the pale markings on the pygidium are connected together (approaching the typical form).

EUCNEMIDAE.

Microrhagus howensis, n. sp.

Deep black; legs reddish, the femora partly infuscated. Clothed with short black pubescence, becoming stramineous about base of prothorax and elytra.

Head with crowded punctures, and with a feeble median carina. Antennae rather short, second joint short, third not quite as long as fourth and fifth combined, eleventh distinctly longer than tenth. Prothorax moderately transverse, parallel-sided except for the rounded front angles, hind angles very acute and acutely carinated, front margin finely carinated, the carina on each side with a short spur directed obliquely backwards, with a short but distinct mediobasal carina; with dense and small, but sharply defined punctures. Elytra almost parallel-sided; with dense, subasperate punctures about base and on tips, elsewhere with smaller ones; with vague remnants of striation, but becoming distinct on the tips. Prosternal sulci narrow and deep in front, becoming shallower and wider

posteriorly; propleural parallelograms feebly concave posteriorly, fully thrice as long as wide. Length, 3·75 mm.

Lord Howe Island (A. M. Lea). Type (unique), I. 5725.

A deep black species with prosternal sulci distinctly less parallel-sided than usual in the genus. The antennae, at most, could be regarded as very feebly serrated.

Fornax howensis, n. sp.

Castaneous-brown, antennae (basal joint excepted) and legs paler. Densely and uniformly clothed with stramineous pubescence.

Head evenly convex, with rather crowded but small punctures; antennary sockets close together and without a connecting carina. Antennae moderately long, second joint very short, third almost as long as three following combined, fourth slightly shorter than fifth, and fifth than sixth, sixth-tenth subequal, eleventh almost as long as ninth and tenth combined. Prothorax large, sides gently rounded and widest at about basal third; with rather small punctures, becoming crowded on sides. Elytra scarcely twice as long as head and prothorax combined, with striation well defined about suture, but rather feeble elsewhere; fairly dense subasperate punctures about base, smaller and sparser elsewhere. Hind coxae terminating almost as a point on each side, greatest length equal to that of two basal segments of abdomen combined; basal joint of hind tarsi about equal to the rest combined. Length, 4·5-6·0 mm.

Lord Howe Island (A. M. Lea). Type, I. 5730.

A comparatively robust species, with prothorax nowhere parallel-sided. One specimen was obtained from a tree-fern, another from a *Kentia,* and four from the summit of Mount Gower.

Fornax norfolcensis, n. sp.

Dark castaneous-brown, antennae and legs paler. Densely and uniformly clothed with short, stramineous pubescence.

Head evenly convex, with small dense punctures; without a carina between antennary sockets. Antennae moderately long, second joint about half the length of third, third slightly longer than fourth and fifth combined, fourth and fifth subequal and slightly shorter than the following ones, eleventh almost as long as ninth and tenth combined. Prothorax moderately robust, sides gently rounded and widest near base, with a feeble median line; punctures small but rather dense and well defined, becoming crowded on sides. Elytra with crowded punctures about base, becoming sparser elsewhere; striation well defined about suture and at base and apex, but rather feeble elsewhere. Hind coxae strongly and evenly diminishing in width to sides, greatest length considerably more than that of second abdominal segment; basal joint of hind tarsi as long as the rest combined. Length, 4·5-6·0 mm.

Norfolk Island (A. M. Lea). Type, I. 5731.

Close to the preceding species, but consistently narrower, darker, and with somewhat shorter antennae. On the smaller specimens the striation has a tendency to disappear about the middle. Seven specimens were obtained, three of which were sieved from fallen leaves.

Fornax talayroides, n. sp.

Bright castaneous, legs somewhat paler. Uniformly clothed with stramineous pubescence.

Head strongly convex; with somewhat crowded punctures; without a carina connecting the antennary sockets. Antennae rather long and thin, second joint very short, third almost the length of three following combined, fourth slightly

shorter than fifth, and fifth than sixth, sixth-tenth subequal, eleventh distinctly longer. Prothorax with sides feebly rounded in front, thence feebly oblique to base; punctures rather small and partly concealed on disc, becoming crowded on sides. Elytra feebly diminishing in width from shoulders; moderately densely granulate-punctate about base, punctures smaller, sparser and less asperate elsewhere; striation distinct about suture, feeble or wanting elsewhere. Hind coxae unusually long, their greatest length fully equal to that of fifth abdominal segment, but rapidly narrowing to a point only on each side; basal joint of hind tarsi slightly longer than the rest combined, claw joint shorter than usual. Length, 4·75 mm.

Lord Howe Island (A. M. Lea). Type, I. 5737.

An unusually narrow species, in general appearance strikingly close to *Talayra elongata* of the Melandryidae. Two specimens exactly alike were obtained; a larger (6 mm.) specimen appears to belong to the species, but is darker, with more depressed clothing and somewhat coarser punctures.

ELATERIDAE.

Glyphochilus basicollis, n. sp.

Piceous-brown and livid-flavous, appendages more or less flavous. Moderately densely clothed with stramineous pubescence, shorter on under than on upper surface.

Head gently convex, evenly rounded in front; with dense, subreticulate punctures. Antennae thin, extending almost to abdomen, third joint about twice the length of second, and half the length of fourth, the others gradually decreasing in length, but eleventh slightly longer than tenth. Prothorax with sides increasing in width towards and coarctate near apex, hind angles large and unicarinate; with unevenly distributed punctures. Elytra narrow, each rather narrowly rounded at apex; with narrowly impressed striae; rather densely granulate-punctate about base, the punctures becoming sparser and less rough posteriorly. Tarsi thin, lobe of fourth joint rather thin and curved. Length, 7·5-8·0 mm.

Norfolk Island (A. M. Lea). Type, I. 5673.

The prothorax is wider at the base than is usual in the genus; but the prosternal sutures opening out and deeper in front are indicative that the species should be referred to *Glyphochilus,* rather than to *Monocrepidius.* It is a curiously mottled species; the head is almost black, with the muzzle pale; the pronotum is mostly pale, but with two large blackish blotches, sometimes conjoined; the elytra vary from almost entirely pale to almost entirely infuscated; the under surface is mostly dark, but with the sides of the prosternum pale, the eight apical joints of antennae have more or less of their basal portions infuscated. The punctures on the prothorax are fairly dense and well defined in the middle (except near base) and become denser towards the front sides, where they are much as on the head; the carina divides the hind angles into two very unequal portions, a small subrugose inner one, and a much wider and almost impunctate outer one. The hind coxae at their longest part are quite as long as the part of the metasternum immediately behind them. Ten specimens were obtained, including one from moss.

Glyphochilus kentiae, n. sp.

Castaneous, appendages castaneo-flavous. With rather dense, stramineous pubescence.

Head with crowded punctures of moderate size. Antennae thin, extending almost to abdomen, third joint almost twice the length of second, and about half the length of fourth. Prothorax with sides obliquely increasing in width to base, moderately strongly to about basal third, less strongly to base; with punctures on front sides much as on head, somewhat smaller about middle, and still smaller and sparser about base; hind angles acute, moderately long and unicarinate.

Elytra gradually decreasing in width from shoulders to apex; narrowly striate; interstices conspicuously granulate-punctate about base, the punctures becoming smaller, sparser, and less asperate posteriorly. Tarsi narrow, lobe of fourth joint thin. Length, 8-9 mm.

Lord Howe Island (A. M. Lea). Type, I. 5672.

The carina of the hind angles of the prothorax is so placed that the outer portion of the angle is considerably larger than the inner. The base of the elytra and the scutellum have a more reddish tone than elsewhere, the base of the head is usually infuscated; the mesosternum and metasternum are somewhat darker than the rest of the under surface. Six specimens were obtained from *Kentia* palms.

Glyphochilus inconspicuus, n. sp.

Piceous, some parts castaneous; appendages of a more or less dingy flavous. Rather densely clothed with stramineous pubescence. Length, 6-8 mm.

Lord Howe Island (A. M. Lea). Type, I. 5675.

Structurally close to the preceding species, but considerably smaller and darker, head with more crowded punctures, antennae somewhat stouter, with third joint not twice the length of second, and less than half the length of fourth, prothorax with a vague median line, carina of hind angles dividing these into more equal parts, and punctures more crowded, elytra more conspicuously granulate and with distinct punctures in the striae towards base. The parts more conspicuously castaneous than piceous are the base and hind angles of prothorax, scutellum, apical half of suture, and sometimes the margins of elytra, and most of the under surface. Four specimens were obtained. A small (6 mm.) specimen probably belongs to this species, but is reddish-castaneous, the flavous legs and infuscate base of head excepted.

Glyphochilus waterhousei, n. sp.

Reddish-castaneous, legs paler, antennae (two basal joints excepted) infuscated. Rather densely clothed with stramineous pubescence.

Head with crowded, subreticulate punctures. Antennae thin, third joint about once and one half the length of second and about half the length of fourth. Prothorax with sides somewhat rounded in front, thence feebly increasing in width to base, median line vaguely defined, hind angles very acute and unicarinate; punctures quite as crowded on the front sides as on head, but rather less crowded elsewhere. Elytra parallel-sided from shoulders to near apex; narrowly striate; with subasperate, scarcely granulate, punctures about base, becoming smaller and sparser posteriorly. Tarsal lobes comparatively wide. Length, 9·5 mm.

Lord Howe Island (A. M. Lea). Type, I. 5674.

The above description is of the smaller of two specimens; the larger (11 mm.) one has the antennae uniformly coloured and very little darker than the legs, two vague infuscate longitudinal blotches on the pronotum, and the outer portion of the basal angles somewhat smaller than the inner (on the type they are about the same size). The elytra of both are much less conspicuously granulate-punctate than on either of the preceding species, although there are a few granules about the base. The type was from the summit of Mount Gower, the larger specimen from much lower down. The species is named in honour of the late Mr. J. B. Waterhouse of the island.

Ochosternus(1) **howensis**, n. sp.

Black with a feeble bronzy gloss, appendages obscurely reddish. Moderately clothed all over with light-brownish pubescence.

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(1) Cand., Mon. Elat., iv., p. 445; Sharp, Ann. and Mag. Nat. Hist., May, 1877, p. 25; Broun, Man. N.Z. Col., p. 298.

Head evenly rounded in front, with the margin shining but not carinated; with dense and rather coarse punctures. Antennae extending almost to abdomen, second joint small, third not much longer, fourth-tenth strongly serrate internally, of almost equal lengths, but slightly diminishing in width, eleventh slightly longer than tenth. Prothorax slightly longer than wide, sides very feebly sinuous, hind angles acute and passing scutellum, acutely obliquely unicarinate; median line rather wide and distinct posteriorly, feeble elsewhere; punctures in front slightly smaller but almost as dense as on head, becoming smaller posteriorly. Elytra rather narrow, feebly and regularly decreasing in width from near base, with the apices somewhat thickened and conjointly rounded; narrowly striate, the sutural stria almost impunctate, the others with more or less distinct and behind the shoulders strong punctures; interstices about base rather densely granulate-punctate, the punctures becoming smaller, sparser and simple posteriorly. Prosternum with moderately dense, but unevenly distributed punctures, intercoxal process acute, narrow, and deflected downwards. Tarsi long and thin, fourth joint simple, claws thin but subdentate near base. Length, 15-18 mm.

Lord Howe Island (A. M. Lea). Type, I. 5676.

Differs from *O. zealandius* in being smaller, with stronger punctures, intercoxal process of prosternum more suddenly turned downwards, and with four feeble carinae between the coxae. Twelve specimens were obtained on the lower parts of the island.

Ochosternus norfolcensis, n. sp.

Black with a slight bronzy gloss, appendages dull red. Moderately clothed with short, brownish pubescence.

Head with rather small and not very crowded punctures. Length, 13-14 mm.

Norfolk Island (A. M. Lea). Type, I. 5677.

Structurally and in general appearance close to the preceding species, but somewhat smaller, with sparser clothing, prothorax with median line more defined, carina on posterior angle longer, and punctures everywhere somewhat smaller, more noticeably on head than elsewhere. On that species the punctures on the head are so close together that an additional one of the same size could scarcely be placed anywhere, without overlapping several others; on the present species many such punctures could be inserted without overlapping the adjacent ones. Two specimens were obtained.

TENEBRIONIDAE.

Mesotretis pubipennis, n. sp.

Of a dingy reddish-brown, under surface and parts of upper surface blackish. Elytra rather densely clothed with semi-erect and rather short, greyish pubescence, somewhat shorter and paler on under surface, still shorter on head and prothorax.

Head wide; with dense and small but fairly sharp punctures; clypeal suture in the form of a shallow, curved impression, slightly deepened close to each antennary ridge. Antennae moderately long, third joint distinctly longer than second or fourth, three apical joints enlarged, somewhat darker than the others, and forming a conspicuous but loosely compacted club. Prothorax strongly transverse, sides gently rounded and widest near apex, apex very gently incurved to middle, lateral margins comparatively wide and slightly dilated to base, each hind angle with a slight outer projection, basal margins very narrow; punctures small and rather dense. Elytra distinctly wider than base of prothorax, shoulders gently rounded, parallel-sided to near apex, with a shallow longitudinal depression on each side of base near the shoulder; punctures dense, sharply defined, and of

moderate size. Under surface with dense and sharply defined punctures, but somewhat uneven in sizes. Length, 4·2-4·5 mm.

Lord Howe Island (A. M. Lea). Type, I. 6621.

Considerably wider than *M. ferruginea* or *fumata,* and with the lateral margins of the prothorax decidedly wider, elytra conspicuously clothed, etc. Probably it would have been referred to a new genus, but for its alliance with *fumata;* the penultimate joint of the tarsi is very slightly bilobed, but still it *is* bilobed, and the clothing of the under surface of the tarsi is as on that species. The head gradually changes from blackish at the base, to the general dingy brown in front; the scutellum, the prothoracic and elytral margins, and a rather wide sutural space are more or less blackish. The elytral punctures are much larger than the prothoracic ones. Six specimens were obtained on tree-ferns on Mounts Gower and Ledgbird.

Mesotretis fumata, n. sp.

Blackish or smoky-brown, in places more or less conspicuously testaceous, appendages testaceous or castaneous, femora sometimes infuscated.

Head with dense and sharply defined but rather small punctures, with a feeble depression close to each antennary ridge. Antennae almost as long as head and prothorax combined, third joint almost as long as fourth and fifth combined, ninth and tenth transverse, their combined length slightly greater than eleventh, and, with it, forming a loosely compacted club. Prothorax moderately transverse, sides gently rounded and slightly wider at apex than at base, lateral and basal margins very narrow; punctures slightly larger and sparser than on head. Elytra distinctly wider than prothorax at base, sides feebly dilated to beyond the middle; punctures somewhat sparser and distinctly larger than on prothorax. Length, 3·5-4·2 mm.

Norfolk Island (A. M. Lea). Type, I. 6620.

In general outlines very close to *M. ferruginea,* except that the prothorax is slightly longer, but very differently coloured, antennary swellings more pronounced, the antennae longer, with the third joint distinctly longer, and the club more loosely compacted; the elytral epipleurae are narrower and the punctures of the upper surface denser and more sharply defined; the clothing of the tarsi is much the same, but the bilobing of the penultimate joint of the four hind ones is less pronounced, although even on *ferruginea* those of the four hind ones are less pronounced than on the front ones. The head, except for the mouth parts, is uniformly black or blackish, the prothorax is usually blackish, but diluted with red at the apex and along a median line; on some specimens the paler markings are very conspicuous, but on others they are scarcely traceable; the elytra are mostly of a dingy testaceous, with the suture and epipleurae narrowly black, and a large but indefinite infuscated patch on each elytron, the patches sometimes but little darker than the ground colour; the sterna are usually blackish, and the abdomen in parts, more especially at the apex, diluted with red. One small specimen has the elytra uniformly almost flavous, except that the suture and margins are narrowly infuscated. From some directions the sides of the elytra appear to have extremely short and sparse pubescence, but it is invisible from most directions. From some directions the prothoracic margins appear to be feebly serrated, but from others they appear to be even. Seventeen specimens were obtaind.

Mesotretis glabra, n. sp.

Black, shining; elytra and abdomen in places obscurely diluted with red, appendages castaneous. Glabrous.

Head moderately wide, evenly convex between eyes, these small; with dense and sharply defined punctures of moderate size in front, becoming very small towards base; antennary ridges rather long and slightly elevated; clypeal suture

feeble. Antennae rather short, second joint slightly longer than third, fourth-eighth smaller, ninth-eleventh slightly larger than the preceding ones, and forming a loosely compacted club. Prothorax rather strongly transverse, base and apex equal, sides gently and evenly rounded, front angles feebly produced, lateral and basal margins narrow; with dense and sharply defined, but not very large punctures. Elytra parallel-sided, outlines almost continuous with those of prothorax; punctures slightly larger than on prothorax, but rather less sharply defined. Length, 4·25 mm.

Norfolk Island (A. M. Lea). Type, I. 6623.

The dense clothing of the tarsi, with the slight lobing of the penultimate joint and considerably narrower elytral epipleurae, are indicative that the species should be referred to *Mesotretis,* rather than to *Araucaricola,* although at first glance it appears to be an unusually narrow specimen of *A. ebenina.* The eyes are somewhat narrower than in all the other known species of *Mesotretis.* The elytra are very faintly shagreened. A single specimen was taken from the dead frond of a tree-fern.

Araucaricola, n. gen.

Head wide; clypeus narrow, at sides elevated into antennary ridges; labrum short. Eyes small, lateral, coarsely faceted. Antennae rather short, with a three-jointed, loosely compacted club. Apical joint of maxillary palpi large and securiform. Prothorax wide, with conspicuous margins. Scutellum very short and wide. Elytra parallel-sided, the width of prothorax, margins narrow and continuous to apex; epipleurae wide at base, and gradually narrowed to apex, concave from base to end of metasternum, convex beyond same. Metasternum rather long, episterna parallel-sided and not very narrow. Abdomen with three basal segments large, the others small. Legs rather short, front coxae slightly separated, almost basal, cavities closed, middle coxae moderately, the hind ones more widely separated; femora stout, tibiae terminated by two small spines, and sexually variable; tarsi short, claw joint about as long as the rest combined, penultimate joint small and simple. Wings ample.

In many respects this genus is close to *Mesotretis,* near which it should be placed, but the eyes are smaller, with a greater proportion on the under surface, elytral epipleurae wider, tarsi more sparsely clothed on the under surface, with the penultimate joint slightly narrower than the preceding one, and not bilobed, and the claw joint considerably longer in proportion. At first glance the penultimate joint appears to be slightly produced under the base of the following one, but this appearance is really due to a few projecting hairs or setae. The sexes may be readily distinguished by the front and hind tibiae. Numerous specimens were taken under rotting bark of the Norfolk Island pine, *Araucaria excelsa;* in general appearance they are much like *Asphalus ebeninus* on a greatly reduced scale.

Araucaricola ebenina, n. sp.

♂. Black, shining; palpi, legs, and parts of antennae castaneous.

Head evenly convex between eyes, with dense and small but sharply defined punctures; an oblique impression from each side of the clypeal suture to behind the eye. Antennae extending to base of prothorax, first joint moderately large, second somewhat shorter than third, and slightly longer than fourth, ninth and tenth transverse, eleventh slightly wider and longer than tenth. Prothorax about twice as wide as long, sides almost parallel but gently rounded in front, front angles slightly produced to clasp the head, margins rather narrow in front, but dilated to base; punctures much as on head. Elytra with outlines almost continuous with those of prothorax; punctures dense, sharply defined, and distinctly larger than on prothorax, but becoming quite as small posteriorly. Front tibiae moderately wide and parallel-sided, but near base suddenly narrowed and curved;

hind tibiae longer than the others (about as long as the third abdominal segment is wide), conspicuously bisinuate and somewhat thickened at apex. Length, 4·0-4·5 mm.

♀. Differs in having somewhat thinner antennae, front tibiae decidedly thinner and not suddenly narrowed near base, and the hind ones much shorter and almost straight.

Norfolk Island (A. M. Lea). Type, I. 6622.

The basal joint of the antennae is black and shining, the following joints are either entirely castaneous, or change from infuscate to castaneous, but the infuscation seldom extends beyond the fourth joint. There is some extremely fine pubescence on the elytra and under surface, but it is invisible from most directions. Several specimens are more of a piceous-brown than black, but probably from immaturity.

Trachyscelis howensis, n. sp.

Colour variable. Under surface, sides and legs with straggling, yellowish or stramineous hairs.

Head scarcely visibly punctate, with a rather deep groove from eye to eye. Antennae short, five apical joints forming a robust club. Prothorax polished and impunctate, sides and base very narrowly margined. Elytra slightly dilated to beyond the middle; each with a distinct subsutural punctate stria from base to apex, a second conspicuous row of punctures, becoming striate posteriorly, then with six rows of small punctures, becoming very feeble towards the side, the side with a marginal slightly punctate stria; interstices sparsely and minutely punctate. Legs short and stout, front tibiae moderately dilated from base but suddenly inflated at apex, the others rather strongly dilated from base to near apex, and with short, dense, stout setae. Length, 3·0-3·5 mm.

Lord Howe Island (A. M. Lea). Type, I. 6589.

In general appearance very close to *T. ciliaris*, but with the ciliation of the sides much less pronounced, and the median line of the pronotum altogether wanting; from *T. laevis* it differs in being larger and more robust, and in the more conspicuous elytral punctures; *T. niger* is a considerably wider species, with stronger striation. Numerous specimens were obtained at roots of beach-growing plants, under seaweed, and washed up wood, etc. Two colour forms appear to be equally abundant; the first, including the type, black or blackish, with the muzzle and sides of prothorax and of elytra more or less distinctly diluted with red, and all the appendages more or less castaneous; the second form is entirely castaneous; but a few specimens are intermediate. The straggling hairs are fairly numerous on the under surface and legs, but rather sparse on the sides of the prothorax and elytra, scarcely one-fourth as dense as on *ciliaris*.

Brachycilibe araucariae, n. sp.

Black or blackish, antennae, palpi and tarsi castaneous, parts of under surface sometimes diluted with red. Under surface almost glabrous, the upper quite so.

Head wide, gently convex, obliquely flattened in front, with a small impression marking each side of the clypeal suture; with moderately dense and sharply defined but rather small punctures. Antennae short, tenth and eleventh joints forming a club, tenth strongly transverse, much wider than ninth, and slightly wider than eleventh, the latter almost circular. Prothorax not twice as wide as long, evenly convex from margins, which are moderately wide throughout, sides gently rounded and wider at base, which is truncate, than at apex, which is feebly incurved to middle; punctures slightly larger than on head. Elytra the width of prothorax, parallel-sided from base to the widely rounded apex; regularly punctate-striate, the striae sharp and well defined, but the punctures rather small and close together, interstices with minute punctures; epipleurae rather wide from

base to near apex, where they are suddenly narrowed by the apical ventral segment, wrinkled and rather finely punctate. Legs short; front tibiae slightly serrated externally and dilated to apex. Length, 3·7-4·0 mm.

Norfolk Island (A. M. Lea). Type, I. 6588.

Fairly numerous in and under rotting bark of the Norfolk Island pine. In general appearance fairly close to *B. antennata*, but slightly narrower cephalic excavation wanting, prothorax narrower at apex and without an apical depression (on *antennata*, although not mentioned in the original description, there is invariably such a depression), elytral striation more pronounced, and legs not quite so stout. Specimens entirely black on the upper surface usually have parts of the under surface distinctly diluted with red, more especially parts of the sterna and the elytral epipleurae; many specimens, however, have the upper surface of a livid-testaceous, with the under surface and legs paler, but variegated with dark brown.

MELANDRYIDAE.

Talayra brevipilis, n. sp.

Black, appendages castaneous-brown. Densely clothed with short, brownish pubescence.

Head with very dense, minute punctures. Eyes large, subreniform. Antennae long and thin, second joint about one-third the length of third, the latter slightly shorter than first, and slightly longer than fourth. Prothorax moderately transverse, sides strongly rounded, base slightly bisinuate, and considerably wider than apex, hind angles obtuse; punctures not quite as dense as on head but of similar size; marginal carina on each side acute about base, but vanishing before the middle. Elytra very feebly diminishing in width posteriorly, slightly but distinctly striated; with very dense and small punctures, somewhat transversely or obliquely arranged towards base. Tibiae transversely serrated on upper surface, serrations on front pair less distinct than on the others, and partly obscured by a longitudinal ridge; spurs to hind pair unequal, the shorter about half the length of the following joint. Length, 11-13 mm.

Lord Howe Island (A. M. Lea). Type, I. 6098.

A long thin species, longer than any other Australian member of the family, except *Ctenoplectron humerale*. From *T. elongata* it differs in its much larger size, darker colour (an occasional specimen of *elongata*, however, is almost as dark), finer punctures, and more conspicuous elytral striation. Although the derm is black, it is everywhere so closely covered by pubescence that to the naked eye it appears to be of a somewhat rusty-brown, but from other directions it appears to have a silken gloss; from some directions the abdominal segments appear to be tipped with golden-red. The punctures are normally somewhat obscured by the clothing. Three specimens were obtained.

TALAYRA ELONGATA, Macl.

Innumerable specimens of this species were seen at night running over the bark of newly-felled trees on Lord Howe Island. In the light of the lamp they had the appearance of small and extremely active ants; larvae and pupae were also seen in the bark of old banyan logs. The length of the island specimens varies from 3 to 6 mm., the average being about 4 mm.

CANTHARIDAE.

Goetymes helenae, n. sp.

♂. Black, elytra, sides of prothorax, antennae (most of rami excepted), palpi, and legs of a more or less dingy light-brown, or testaceous. Densely clothed with very short, dark pubescence.

Head lobed at base, with a slight but distinct median line; with crowded punctures, well defined about base, but with a subgranulate appearance elsewhere. Eyes deeply semi-circularly notched, median portion very thin, inner lobe smaller than outer, the notched space gently convex and with crowded punctures. Antennae inserted slightly in front of eyes, first joint curved and moderately stout, the nine following ones very short, but the fourth to tenth each with a very long ramus, eleventh joint almost as long as the ramus of tenth. Prothorax at base wide and very slightly sinuate, sides strongly diminishing in width to apex, which is hardly more than one-third the width of base of head, with a moderately well-defined median line, a rather shallow longitudinal impression on each side; with crowded and rather small punctures. Scutellum with a median ridge, punctures as on pronotum. Elytra slightly wider than base of prothorax, sides from near base strongly narrowed to about middle, and then subparallel to near apex; each with three feeble longitudinal elevations, of which the one nearest the suture is longer and more distinct than the others; with dense and minute punctures. Abdomen extending well beyond elytra. Legs long and thin. Length, 7·75 mm.

Lord Howe Island (Mrs. A. M. Lea). Type, I. 6142.

Much smaller and otherwise different from the previously described species of the genus. The clothing of the head from directly above is rather indistinct, but when viewed from the sides is seen to be dense and erect, although short. The prothorax is so narrow in front, and wide at the base, that at first glance it appears to be almost triangular. A single specimen was taken on the summit of Mount Gower by my wife, after whom I have named it. It is one of the most curious species occurring on the island.

CURCULIONIDAE.

Eutinophaea bicristata, n. sp.

♂. Dark reddish-brown, legs and antennae paler. Densely clothed with fawn-coloured scales mixed with darker and paler ones, on the under surface almost white. In addition with sloping setae, mostly dark, but varying to whitish.

Head with dense, concealed punctures. Eyes almost round. Rostrum with a feeble median line, muzzle glabrous; scrobes with upper portion rather short and wide, lower portion narrow and oblique. Scape somewhat curved, apex stout, two basal joints of funicle rather long, the first longer and stouter than second. Prothorax strongly convex, about as long as the greatest width, sides strongly and evenly rounded, punctures normally concealed. Elytra not much wider than widest part of prothorax, but considerably wider than its base, almost parallel-sided to beyond the middle; with rows of large, partly concealed punctures, odd interstices slightly elevated above the even ones, but the third abruptly and strongly elevated into a setose crest from slightly beyond the basal third to near the summit of the apical slope, the beginning of the crest usually black. Abdomen with first segment slightly concave in middle. Front tibiae rather strongly curved. Length 2·7-3·2 mm.

♀. Differs in having the prothorax slightly longer, its sides less inflated, and two basal segments of abdomen rather strongly convex.

Queensland: Montville, in August (W. A. T. Summerville); Mount Tambourine, in January (A. M. Lea).

Very distinct from all other known species of the genus by the conspicuous crests on the elytra of the male, on the female the crests are only slightly indicated. There are usually two curved dark spots at the base of the prothorax and several small ones on the elytra, the paler spots are mostly confined to the sides of the prothorax and the apical slope of the elytra, but on several specimens the clothing of the upper surface is almost uniformly brown.

Mr. R. Veitch, Chief Entomologist of the Queensland Department of Agriculture, reports that this species is destructive to citrus foliage; the "Dicky Rice" *Eutinophaea spinipes* Blackb. (*Prosayleus phytolymus* Olliff), of orchardists near Sydney is also troublesome to citrus fruits.

CERAMBYCIDAE.

Oberea mundula Pasc.[2]

A very narrow longicorn from Cairns (Queensland) and another from the Madang district (New Guinea) appear to belong to this species, originally described from Waigiou and Salwatty. They are of a rather dingy flavous-red, with the elytra, except for the basal sixth, four apical segments of abdomen (a small part of the base of each excepted) and the antennae black or blackish. The figure[3] of *O. gracillima* will give a good general idea of the species, except that the figure has less of the base of elytra pale, and the antennae longer.

Eczemotes[4] conferta Pasc.[5]

Specimens of this species have been taken at the Coen River (Queensland) by Messrs. W. D. Dodd and H. Hacker. It was originally described from Aru, and as a *Penthea*, but was subsequently made the type of the genus *Eczemotes*.

Somatidia olliffi, n. sp.

Pale castaneo-flavous. Head, under surface and appendages, with whitish pubescence, and some scattered hairs; prothorax sparsely pubescent and with some long hairs, of which those in front are directed backwards; elytra without pubescence, but with numerous long hairs subseriately arranged.

Head with dense fine punctures, and some of larger size between eyes. Antennae distinctly passing elytra, fourth joint slightly longer than third. Prothorax moderately transverse, sides strongly and evenly rounded; with fairly dense and moderately large punctures, becoming smaller and sparser about base. Elytra ovate, widest at about basal third; with larger punctures than on prothorax, but becoming much sparser and smaller posteriorly. Femora stout, front tibiae short and feebly notched on lower surface, middle tibiae feebly notched on upper surface; hind tibiae slightly longer than the others, but not notched. Length, 3-4 mm.

Lord Howe Island (A. M. Lea). Type, I. 5460.

A small pale species, of which seven specimens were beaten from a recently felled *Pandanus* tree. The clothing of the prothorax is to a certain extent as on *S. capillosa*, but the elytra are entirely without pubescence, although with numerous long hairs; these appear to be in five rows on each elytron, but the sutural and lateral rows are rather feeble. The tarsi, especially the front pair, are very wide on both sexes.

Somatidia tricolor, n. sp.

Head, prothorax and under surface dark-reddish-castaneous, elytra bronzy, with a slight greenish gloss; appendages flavous; parts of antennae slightly infuscated. Clothed with fine, ashen pubescence, and with fairly long hairs, more noticeable on prothorax and elytra than elsewhere.

Head with dense and fine punctures. Antennae distinctly passing elytra, fourth joint longer than third. Prothorax distinctly transverse; with dense but not very large punctures, becoming smaller about base. Elytra ovate, widest at

(2) Pascoe, in Longicornia Malayana, in Trans. Ent. Soc. Lond., iii. (Ser. 3), 1867, p 432.

(3) *L.c.*, pl. xvi., fig. 9.

(4) *L.c.*, p. 79.

(5) *L.c.*, p. 80; and v. (Ser. 2), p. 40.

about basal third, with dense and large punctures, in places subconfluent, but becoming much smaller posteriorly. Legs much as on preceding species. Length, 3 mm.

Lord Howe Island (A. M. Lea). Type, I. 5461.

The colours are much as on *S. aranea,* but the elytra are clothed both with pubescence and long hairs, the latter are more or less upright and in five or six rows on each elytron. There are fairly numerous hairs on the front of the prothorax, nearly all directed backwards, but the species is much smaller and otherwise very different from *S. capillosa.* Two specimens, apparently males, were obtained, one by sieving fallen leaves.

Somatidia villosa, n. sp.

Head, prothorax and under surface dark-reddish-castaneous, elytra bronzy, appendages flavous but with third to eleventh joints of antennae and middle of femora and of tibiae somewhat infuscated. Clothed with fine ashen pubescence, sparser on prothorax than elsewhere; with numerous very long yellowish hairs.

Head with dense small punctures, interspersed with some larger ones. Antennae distinctly passing elytra, third joint scarcely longer than fifth and conspicuously shorter than fourth. Prothorax moderately transverse, sides strongly and evenly rounded; with crowded but not very large punctures. Elytra ovate, at basal fourth almost twice the width of extreme base; with crowded punctures slightly larger than on prothorax, but almost vanishing posteriorly. Femora very stout; front tibiae conspicuously notched on lower surface. Length, 3·5-5·0 mm.

Lord Howe Island (A. M. Lea). Type, I. 5459.

Readily distinguished from the other island species by the very long hairs, many of those on the elytra are quite as long as the prothorax is wide, many also are curved forwards or sideways; on the prothorax, antennae and legs also, the hairs are of quite unusual length. On *S. capillosa,* a considerably larger species, the long hairs on the elytra are much shorter and more rigid; the longer hairs on its antennae are fairly numerous, but much shorter than their supporting joints, and nearly all project downwards; on the present species the long hairs are often quite as long as their supporting joints, and on about eight of the joints are fringe-like near the tips; on the pronotum, also, the majority of the long hairs in front do not conspicuously project backwards as on most species of the genus. Five specimens were obtained, three by sieving fallen leaves.

The genus *Somatidia* is abundantly represented in New Zealand, but as yet species are unknown from the mainland of Australia; those from Lord Howe Island may be tabulated as follows:—

A. Prothorax longer than wide, size 10 mm.(6) .. .. *pulchella*
AA. Prothorax transverse, size much less than 10 mm.
  B. Elytra glabrous (7) .. .. *aranea*
  BB. Elytra not glabrous.
    C. Elytra with long hairs but without pubescence .. .. *olliffi*
    CC. Elytra with long hairs and pubescence.
      D. Long hairs on antennae frequently as long as their supporting joints .. *villosa*
      DD. Long hairs on antennae always much shorter.
        E. Legs uniformly pale .. .. *tricolor*
        EE. Legs not uniformly pale .. .. *capillosa*

Porithea parenthetica, n. sp.

Rusty-brown, elytra (a subtriangular basal space and an irregular postmedian blotch excepted), basal half of femora, tibiae (tips excepted), parts of tarsi and antennae (tips excepted) of a more or less dingy flavous. Clothed with

(6) From description.

(7) There are usually, but not always, from one to three hairs on the base of each elytron.

very short, pale pubescence, denser and more sericeous in appearance on the prothorax and under surface than elsewhere; a few long hairs scattered about, but becoming numerous on antennae.

Head with small, dense, concealed punctures; clypeal suture subfoveate on each side, median line well-defined except posteriorly. Antennae slightly passing

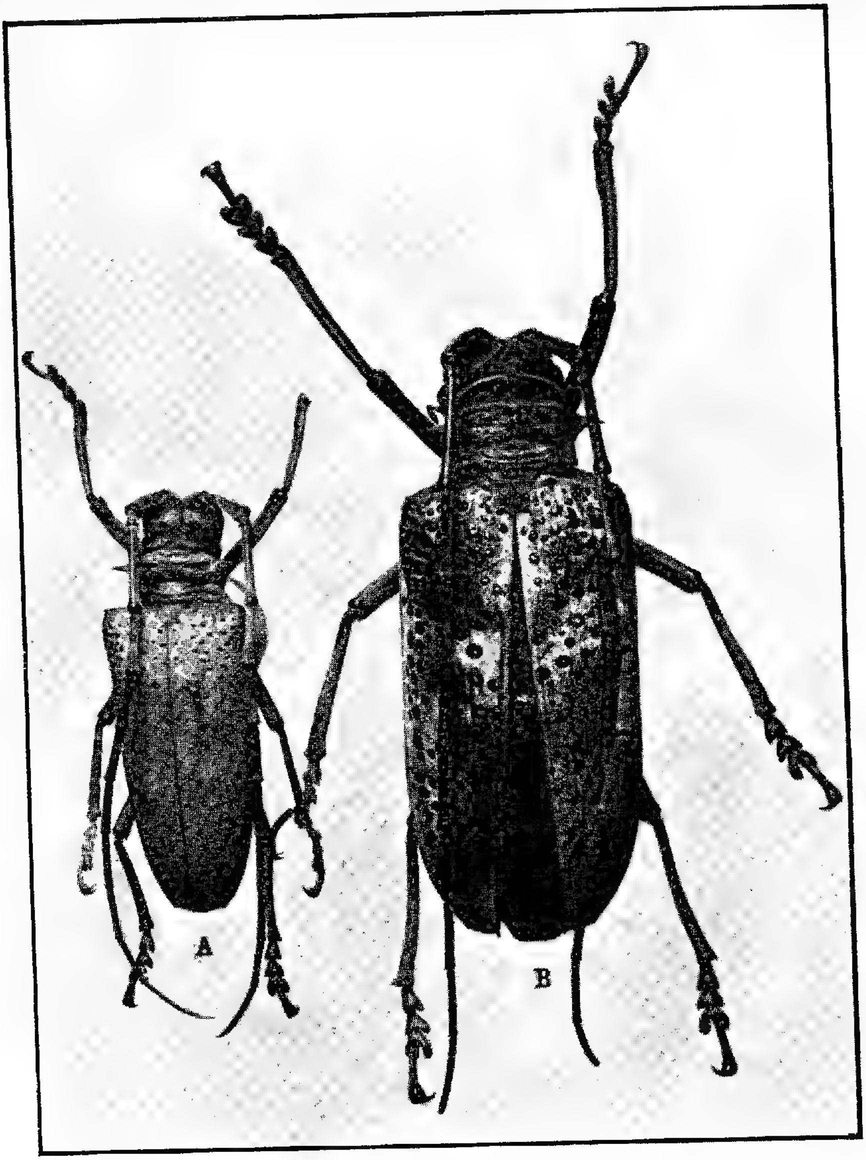

Fig. 4.
Rosenbergia megalocephala v. d. Poll., natural size.
A, from Queensland; B, from Komba.

elytra in female, considerably in male, spine at tip of third joint very distinct; on the fourth and fifth much shorter. Prothorax distinctly longer than wide. sides rounded and widest slightly in front of middle; with three discal elevations, a median one not continuous to base or apex, and two parentheses-like ones;

punctures dense but rather small. Elytra not much wider than greatest width of prothorax, parallel-sided to near apex, where each is separately rounded; about base with dense and rather coarse punctures, gradually becoming sparser and smaller, till at the apex they are very small and sparse; with two vaguely elevated lines on each elytron. Femora clavate. Length, 12-17 mm.

Lord Howe Island (A. M. Lea). Type, I. 5452.

Structurally close to *P. plagiata*, but with very different markings. The darker parts of the elytra are somewhat variable, the subtriangular basal space is somewhat dilated about the shoulders, and on five of the specimens is connected along the suture with the postmedian blotch, this is widest at the suture, and rapidly narrows to the middle of each elytron, where it sometimes terminates, but on some specimens it is irregularly angularly connected with the sides; the sides at the base are usually infuscated. The elevations on the prothorax are roughly like (I), the outer ones, however, are somewhat swollen at their ends, so as to appear like obtuse tubercles. Owing to the clothing the prothoracic punctures are not very sharply defined; on the elytra, in addition to the ordinary ones, there are some slightly larger ones in feeble series, a row close to the suture on each side is readily seen, but not the others; the linear elytral elevations are fairly distinct on some specimens (although not sharply defined), but scarcely traceable on others. The male is smaller than the female, with the prothorax somewhat longer, antennae and legs longer, and front tibiae rather more noticeably (although not strongly) curved, and somewhat wider at the apex. Twelve specimens were taken on trunks of newly felled trees at night.

Rosenbergia megalocephala v. d. Poll, var.

A specimen from New Guinea (Komba, Rev. L. Wagner), appears to represent a variety of this species. It is longer (70 mm.) than any specimen I have seen from Australia, and the shining granules on the elytra are larger, more numerous and more evenly distributed, although more numerous about the shoulders than elsewhere. It has some ochreous patches of pubescence on the head and prothorax, and at the base of elytra. In the accompanying photograph (by Mr. B. Cotton) it is shown beside a specimen of normal size from Queensland.

CHRYSOMELIDAE.

Chrysomela multimaculata, n. sp.

Pale flavous, with numerous black spots.

Head with crowded punctures of moderate size; clypeal suture gently arched. Antennae long and thin. Prothorax about thrice as wide as the median length, front angles produced, hind ones obtuse; punctures about as large as on head but less crowded. Elytra slightly dilated to beyond the middle; with rows of rather large punctures, becoming smaller posteriorly, the interstices with numerous small punctures; epipleurae narrow, not at all concave. Legs moderately long, claws simple. Length, 7 mm.

South Australia: Barton (A. M. Lea). Type, I. 17111.

The intercoxal process of the prosternum is narrow and very feebly bilobed at the base, but other characters agree with those of *Chrysomela*. Its markings are very different from those of any other species of the subfamily before me. The black markings on the type are:—Four transverse spots on the head (two between eyes and two at base); four across middle of prothorax, three series of spots and vittae on elytra, a spot on each metasternal episternum, knees, tips of tibiae, tarsi, antennae (except parts of three basal joints), apical joint of palpi, and the jaws. Of the series on each elytron the first consists of a spot touching the suture, and narrowly connected at the base with a humeral vitta, which diverges

posteriorly to form a reversed Y, a free vitta on the fourth, and a longer one on the sixth connected with the base; the second consists of a curved series of three spots at the basal third, of which the curve includes the tips of the Y; the third consists of three spots beyond the middle, and a narrow vitta extending to near the apex; the apical third of the suture is also narrowly black. A second specimen has markings much as on the type, except that on the left elytron the inner arm of the Y is free, and that on the right one it is almost free. Some of the elytral interstices are much wider than others, the outer one is widest of all.

Calomela flavida, n. sp.

Flavous, five or six apical joints of antennae more or less deeply infuscated.

Head with rather numerous and small but sharply defined punctures; clypeus with somewhat smaller punctures than on the surface behind it, its suture widely triangular. Antennae comparatively long and thin. Prothorax more than thrice as wide as long, sides gently decreasing in width to beyond the middle, and then more strongly to apex; punctures somewhat sparser and stronger than on head but becoming very small in front. Elytra with outlines continuous with those of prothorax; with regular rows of rather small punctures, the interstices with minute punctures. Length, 5-6 mm.

Queensland: National Park, in November (H. Hacker). Type, in Queensland Museum; cotype, in South Australian Museum.

A small, pale species, about the size of *C. vacillans*, and very similarly coloured, but seriate punctures of elytra regular and much smaller (owing to "waterlogging," however, they appear much larger than they really are), prothorax less transverse and with much smaller punctures. *C. tarsalis* has considerably wider antennae and dark tarsi. *C. pallida*, and the pale variety of *C. crassicornis*, have wider antennae and much coarser punctures on sides of prothorax and on head. *C. monochromatea, geniculata, flavescens*, and *cephalotes* are more elongate species. *C. intemerata* has entirely pale antennae, and *C. bimaculiceps* has bimaculate head, etc. The seriate punctures on the elytra are not one-fifth of the width of the interstices, but owing to "waterlogging" about the base from some directions they appear to be almost as wide, posteriorly, however, their apparent size becomes much smaller. The largest punctures are on the metasternum. On two of the specimens the third joint of the front tarsi is somewhat infuscated.

Calomela maculiceps, n. sp.

Of a dingy brownish-flavous, a large medio-basal spot on head, six apical joints of antennae, tips of palpi, scutellum, metasternum, knees, tibiae and tarsi black or blackish.

Head with fairly large punctures mixed with minute ones, clypeal suture rather feeble and irregular, with a feeble median line. Antennae long and thin, no joint transverse. Prothorax more than thrice as wide as long, sides feebly diminishing in width to near apex; with mixed punctures as on head. Elytra very little wider than prothorax; with regular rows of moderately large punctures, becoming smaller and closer together posteriorly; interstices with minute punctures. Punctures on metasternum almost confined to the margins. Legs stout. Length, 6 mm.

Queensland: Rockhampton. Type, I. 17105.

A rather narrow species, distinct from all the other pale species by the single spot on its head and the black scutellum. *C. bimaculiceps*, to which it is structurally close, has the head bimaculate and legs partly blue. The prothorax itself is actually immaculate, but, owing to its transparency, appears to have a continuation of the spot on the head.

Calomela picticornis, n. sp.

♂. Bright metallic green, with a coppery gloss, under surface and base of femora reddish, four basal joints of antennae reddish, the four following ones black, the three apical ones white, but tip of eleventh infuscated.

Head with a few distinct punctures in front, clypeal suture deep, a short median line joining its middle. Antennae short and dilated to near apex, with several joints transverse. Prothorax about thrice as wide as long; with rather small but sharply defined punctures, slightly larger and more numerous on sides than in middle, but nowhere crowded. Elytra scarcely wider than prothorax at base; with regular rows of rather small but sharp punctures, the interstices with scarcely visible punctures. Apical segment of abdomen impressed in middle. Claws bifid. Length, 4·5-5·0 mm.

♀. Differs in having six apical joints of antennae black, apical segment of abdomen evenly convex, and basal joint of tarsi smaller.

Queensland: National Park, in October and November (H. Hacker). Types, in Queensland Museum; cotypes, in South Australian Museum.

A small, compact, metallic green species with distinctive antennae in male. The anterior end of the intercoxal process of the prosternum slopes downwards, so the species is evidently not a small *Augomela*, as it appears at first, but may be referred to *Calomela* and to the vicinity of *C. ruficeps* and *pulchella*, although it is somewhat wider in proportion than those species. Of two females one agrees perfectly in colour (except for the antennae) with the type, the second has each shoulder and most of the pronotum more coppery. A second male has the elytra greenish-purple, but is possibly immature.

CALOMELA GENICULATA Baly, var.

A specimen from Queensland differs from the typical form of this species in having the femora, except the base, tibiae and tarsi black.

CALOMELA MACULICOLLIS Boi., var.

A specimen, from the Upper Williams River, appears to connect *C. gloriosa* with the typical form of *C. maculicollis;* it has the brilliant blue elytra with black suture and sides of the former, the prothorax has a medioapical blue vitta, and a small spot on each side, and the head is entirely pale.

CALOMELA APICALIS Blackb.

In his description of the elytra of this species Blackburn wrote, "the punctures scarcely running in rows except near the apex." This is not correct. On the type and a cotype they are in quite distinct, although irregular rows. Three specimens, from Kuranda, mounted on one card by Mr. F. P. Dodd, evidently belong to the species, but only one agrees with the type; the others have the elytra of a beautiful deep blue, with more of the margins reddish, and the abdomen entirely pale, parts of the legs are metallic blue. These specimens agree well in colour, except that less of the legs are red, with the description of *C. cingulata,* but are much less (6 mm.) than the length (9 mm.) of that species, although the range of length is equalled by several species *(C. ioptera, pallida, digglesi,* and *suturalis).* Another specimen, from Bathurst Head, agrees well with the type.

Stethomela mirogastra, n. sp.

♂. Deep metallic green with purple markings, under surface black, labrum antennae, palpi and legs, femora excepted, flavous.

Head with sparse punctures, but becoming dense and moderately large on and about clypeus; clypeal suture deep on sides, foveate in middle. Prothorax

about four times as wide as the median length, front angles produced; with minute punctures and numerous fairly large scattered ones, becoming larger on sides, and crowded in a subbasal depression near each side. Elytra not much wider than prothorax, with regular rows of fairly large punctures, becoming larger in a posthumeral impression on each side, below which the side is dilated; interstices with minute punctures. Abdomen with an equilaterally triangular hairy flap, extending from near apex of the basal segment almost to apex of the second, apical segment with a large depression, bounded posteriorly by a pubescent ridge. Legs stout, each claw with a large basal appendix. Length, 7 mm.

♀. Differs in having the basal segment of abdomen simple, and the apical one with a median line not bounded by a hairy ridge.

Queensland: Nanango district in November (H. Hacker). Types, in Queensland Museum.

Very distinct by the abdomen of the male. At first glance the species apparently belongs to *Augomela*, but the antennae are decidedly longer and thinner than in that genus. Baly considered *Stethomela* and *Augomela* as subgenera of *Australica* (= *Calomela*); they are certainly closely allied, and, except for the antennae, I would certainly have referred this species to *Augomela*. Both antennae of the male are broken off short, but on the female they are long, thin, and somewhat dilated to apex, with no joint transverse. The purple parts of the upper surface of the male are the head, base, apex and sides of prothorax, and suture, sides and a fascia at basal third of elytra. On the female the purple parts are mostly replaced by blue or purplish-blue.

Stethomela armiventris, n. sp.

♂. Brilliantly metallic, most of under surface and parts of legs reddish, clypeus and antennae flavous.

Head with irregular punctures on and about clypeus, sparse elsewhere, clypeal suture well defined, a narrow median line meeting its middle. Antennae rather long, no joint transverse. Prothorax almost four times as wide as long, sides evenly rounded; with dense and small but fairly sharp punctures, and with numerous rather large ones on sides. Elytra slightly wider than prothorax, sides nowhere quite parallel; with regular rows of punctures of moderate size, the interstices with small punctures as on pronotum. Abdomen with two triangular flaps, the first on the first segment, the other on the fifth. Legs stout. Length, 6·5-7·0 mm.

♀. Differs in having the abdomen simple.

South Australia (Blackburn's collection). Type, I. 2671.

With a remarkable abdomen somewhat as on the preceding species; the triangular hairy flap on the basal segment is much as on that species, but the apical segment also has a triangular flap, overhanging a semi-circular hairy excavation, which, on account of the flap, appears bilobed. The prothorax has the sides more rounded, the small punctures are larger and more numerous, and the large ones are smaller and sparser. The types were queried in the Blackburn collection as *Augomela pretiosa* Baly, but they differ considerably from the description of that species in colour, which apparently, except for a "violet-blue iridescence" was uniform on the upper surface, whereas on this species the prothorax and elytra have conspicuous markings; the antennae also were "black, rather longer than the thorax, the four basal joints pale piceous"; on this species they considerably pass the prothorax, and are not black. I think it possible that *pretiosa* was really founded upon a variety of *A. hypochalcea,* the male of which has a normal abdomen. The greater portion of the upper surface is metallic green or blue, with purple markings on part of the head, base apex and sides of prothorax, suture and a median vitta on each elytron extending from the middle of the base

almost to the apex, and traversed at the basal third by a wide fascia, which does not quite touch the suture. Although labelled as from South Australia, I think the types were really from Queensland or northern New South Wales.

Stethomela ventralis, n. sp.

♂. Dark metallic coppery-green with purple reflections, prothorax, scutellum and under surface reddish, legs reddish and black, antennae black, some of the basal joints flavous.

Head almost impunctate, except on and about clypeus; clypeal suture semi-circular, a narrow median line joined to its middle. Antennae long and thin. Prothorax four times as wide as long, sides straight to near apex, with small scattered punctures and a foveate impression near each side. Elytra nowhere quite parallel-sided; with regular rows of punctures of moderate size, larger on a posthumeral depression than elsewhere, interstices scarcely visibly punctate. Abdomen with a wide notched flap near apex of first segment, fifth large, with a complicated hairy flap occupying the median half, the intervening segments incurved to middle. Legs stout, basal joint of each tarsus dilated. Length, 6 mm.

Queensland: National Park, in December (H. Hacker). Type, in Queensland Museum.

Differs from the males of the two preceding species in having the appendage of the basal segment of abdomen wide and notched at tip, instead of triangular, the apical segment is also more complicated. The antennae are unusually thin, and extend past the hind coxae. There are dense punctures on the pronotum, but they are almost invisible under a magnifying glass. Two males were taken, and they agree perfectly in details of sculpture, although differing in colour of prothorax and parts of under surface. As the specimen with reddish prothorax has perfect antennae, it has been made the type.

Var. Pronotum coloured as head and elytra; most of abdomen and of legs, and sides of metasternum black; basal joint of antennae flavous (the rest missing).

STETHOMELA DISCORUFA Lea, var.

A specimen, from Queensland, is entirely pale, except for a narrow black ring on each elytron, the two touching at the suture; on other varieties the ring-like mark on each elytron is broken, and on some of them parts of the head and prothorax are blue.

STETHOMELA FULVITARSIS Jac.

Of this species, originally described as "dark aeneous the thorax with a greenish the elytra with a violaceous tint," and distinct by its pale labrum, antennae, palpi and tarsi, there are three specimens before me, from Cairns and Kuranda, all of which have the prothorax black without the least tinge of green; two of them have a violaceous tint on the elytra (very faint on one specimen), but on the third the elytra are deep metallic green.

Chalcomela erythroderes, n. sp.

Dark metallic coppery-green, suture narrowly purplish, head with purplish reflections, prothorax and under surface, except part of abdomen, red, clypeus, antennae, and most of legs black, rest of legs reddish.

Head with small punctures, but becoming stronger and crowded on clypeus; clypeal suture deep and well-defined, a deep median line joining its middle. Antennae moderately long, dilated to apex, but no joint transverse. Prothorax about four times as wide as long, sides straight to near apex, front angles well produced; with rather sparse and small punctures. Elytra briefly cordate, scarcely longer than wide; with regular rows of punctures of moderate size,

becoming smaller posteriorly, the interstices with minute punctures. Legs stout. Length, 6-7 mm.

Queensland: National Park, in November and December (H. Hacker). Type, in Queensland Museum.

A briefly ovate species, and the only known Australian member of the genus with the prothorax red. The claws are evenly and slightly dilated to the base, certainly not strongly dentate as on *Stethomela*. On *S. caudata* and *purpureipennis*, however, the dentition is not distinct from most directions, but those species are longer in proportion.

Chalcomela aulica, n. sp.

Brilliant metallic green, purple and coppery; under surface, including inner parts of elytral epipleurae, most of legs and parts of muzzle reddish; antennae black, parts of basal joints reddish. Length, 6 mm.

Queensland: National Park, in November (H. Hacker). Type (unique), in Queensland Museum.

Structurally as described in preceding species, but prothorax and elytra brilliantly metallic. From *C. illudens*, and some specimens identified with doubt as *C. variegata*, it differs in its red under surface, and more conspicuous purplish markings of prothorax and elytra. The head is green, becoming purplish in front, and coppery at the base; the pronotum is narrowly purplish in front, widely purplish at base; and coppery-green across the middle; the elytra are mostly green, and coppery-green, with the suture purple, there is also a purple stripe from the side to the fourth interstice on each elytron, at the basal third, with a branch extending on and about the fifth interstice almost to the apex.

Chalcomela insignis Baly, var (?).

A specimen, from Moa or Banks Island, probably represents a variety of *C. insignis*, it agrees perfectly in structure with typical specimens of that species, but is entirely without coppery or coppery-green markings on the elytra; there are, however, two shades (indistinct to the naked eye) on the elytra, deep metallic blue and purple. At first glance it looks like a large specimen of *Geomela nobilis*, but the intercoxal process of the prosternum is different, and the head has a conspicuous median line.

Lamprolina minor, n. sp.

Dark metallic coppery-green, head and sides of prothorax obscurely diluted with red, antennae black, legs black and red.

Head with small scattered punctures; clypeal suture deep and curved, a deep median line joining its middle. Antennae stout, but no joint transverse, eleventh one-fourth longer than tenth. Prothorax almost four times as wide as long; with numerous minute punctures, and with a few large ones towards sides. Elytra elliptic-cordate, sides nowhere parallel; with rows of small punctures, becoming smaller posteriorly, interstices with minute punctures; with a rather large post-humeral impression, on which the punctures are somewhat larger than elsewhere. Length, 6 mm.

Queensland: National Park, in December (H. Hacker). Type (unique), in Queensland Museum.

Allied to *L. simplicipennis* and *discoidalis*, from the former distinguished by its smaller size, darker prothorax and more distinct series of punctures on elytra; from the latter by its smaller size, coppery gloss of elytra, with smaller punctures and darker head and prothorax.

PHYLLOCHARIS BICEPS Lea.

The types of this species, and of its variety *alternata,* are in the Macleay Museum. Five specimens recently taken by Mr. H. Hacker, at Nanango, and in the National Park of Queensland, appear to belong to the species, but no two have the markings exactly alike. Their prothoracic and elytral markings are as follows: –

1. Prothorax with two complete black vittae, and a large spot in each front angle. Elytra with ten spots, the two apical ones conjoined to form a fascia not quite touching the sides. Fig. 5, A.
2. Prothorax as No. 1, except that the lateral spots are absent. Elytra with eight free spots, the antemedian ones conjoined to form a very irregular fascia, apical spots narrowly separated at suture. Fig. 5, B.
3. As No. 2, except that the prothoracic vittae are very narrow in front, and the lateral spots are slightly indicated.

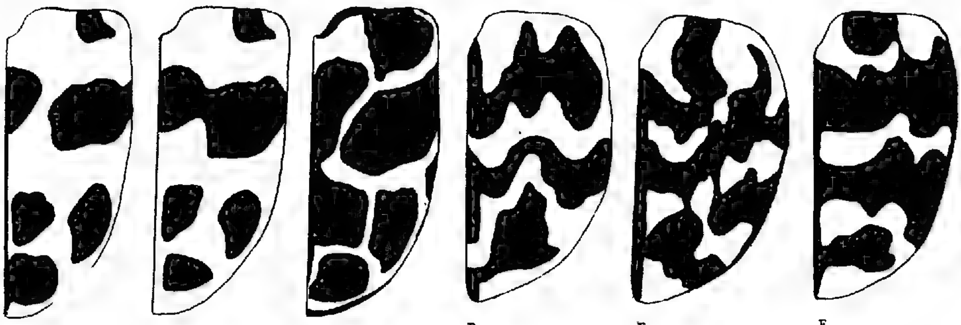

Fig. 5.
A, B, C, Elytral patterns of *Phyllocharis biceps* Lea; D, of *Oomela trifasciata* Lea; E, of *O. hieroglyphica* Lea; F, of *O. picta,* Lea.

4. Prothorax with two longitudinal vittae, spots in front angles slight infuscations only. Elytra with two free basal spots, three antemedian ones, three postmedian (the two median ones of other specimens conjoined) and a subapical fascia (representing the two free spots of other specimens).
5. Prothorax with four black vittae, the median ones about twice as wide as the others. Elytra with eight large free spots, and two large ones conjoined at the suture. Fig. 5, C.

It is probable that the name is a synonym of *P. leoparda* Baly, but in the description of that species the prothorax is described as having *"lineis duabus interruptis—nigris";* and "on either side the medial line is a narrow longitudinal line, interrupted in the centre, pitchy black, just within the anterior angle is also a small spot," and the elytra as having eleven spots.

EULINA.

In my table of the Chrysomelides[8] this genus was placed with those having "FF. Apical joint of maxillary palpi securiform." This was an error, that joint is transversely oblong, and the genus should have been placed with "F. Apical joint of maxillary palpi not securiform" and associated with *Oomela,* from which however, it differs in many respects. The typical species, *E. curtisi,* is a well-known insect, occurring on the wild clematis vine near Sydney.

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(8) Lea, Trans. Roy. Soc. S. Austr., 1916, p. 397.

Eulina pulchra, n. sp.

Red and black, the elytra, in addition, with white fasciate markings.

Head with a few large punctures; clypeal suture curved and deep, a deep median line extending backwards from it almost to the base. Antennae long. Prothorax almost twice as wide as long, sides dilated near apex, all angles rectangular; with some coarse punctures, in places conjoined to form subfoveate impressions. Elytra elongate, about one-fourth wider than base of prothorax, shoulders rounded, sides subparallel to beyond the middle; with rows of punctures of varying sizes, mostly large between the humeral and postmedian markings and small posteriorly, the interstices almost impunctate. Length, 8 mm.

New South Wales: Barrington Tops (J. Hopson). Type, I. 17124.

Differs from *E. curtisi* and *vittata* in having sparser and coarser punctures on the prothorax, different markings on the elytra, and tibiae entirely black; the latter species has decidedly larger punctures on the elytra, with more convex interstices. The general colour is red, the prothorax has a median infuscate vitta, the antennae, tibiae, tarsi, and tips of femora are black, the elytra are black, with a slight metallic gloss, and with an irregular, white, curved mark near each shoulder, an irregular, postmedian white fascia, and a still more irregular subapical one, with a few disconnected whitish spots; the punctures on the white parts are usually infuscated, there are also the remnants of a reddish fascia at the basal third.

A specimen from Dorrigo (W. Heron) probably belongs to the species, but differs in having the white markings on the elytra more apparently composed of short, conjoined, and slightly elevated vittae, the reddish fascia at the basal third paler and more broken up, and the femora black, except for a pale subapical ring.

Eulina haematosticta, n. sp.

Pale flavous, antennae (upper surface of the first joint darker), six spots on elytra, knees and tarsi red.

Head almost impunctate, clypeal suture well defined, a slight curved impression some distance behind it. Antennae long and thin. Prothorax about once and one-half as wide as long, sides quite straight to near apex, apex strongly incurved to middle, base bisinuate; with rather small, scattered punctures, a curved impression directed towards each hind angle. Elytra distinctly wider than prothorax, sides scarcely dilated to beyond the middle; with rows of small to minute punctures, a shallow posthumeral depression on each side. Intercoxal process of prosternum with two rows of large punctures, notched posteriorly; claws with a large basal appendix. Length, 10 mm.

Queensland: National Park. Type (unique), in Queensland Museum.

An elongate, pale species, with three blood-red spots on each elytron; one on the shoulder, one on the middle at the basal third, and one, directly behind it, fairly close to the apex. In its thin antennae it differs from *Calomela*, and by my table of the subfamily it could be referred to *Eulina*, to which accordingly I refer it, although its appearance is very different from that of *E. curtisi*, and the other species of the genus. From some directions the elytra appear to be closely covered with fairly large punctures, or watery-looking spots, but this is entirely due to "waterlogging"; from oblique directions the seriate punctures are seen to be quite small, and they almost vanish posteriorly. On the type parts of the legs are still greenish, and it is probable that in life the insect, except for the parts now reddish, is entirely green.

Pseudoparopsis amplipennis, n. sp.

Head reddish, the base deeply infuscated, prothorax and scutellum black, front margins of the former narrowly reddish, elytra deep coppery-green, their

epipleurae black, under surface and legs red, antennae black, the basal third reddish.

Head with small scattered punctures, clypeal suture distinct, a well-defined median line joining its middle. Antennae moderately long, fifth-tenth joints transverse. Prothorax at base more than four times as wide as long, sides evenly rounded, apex strongly incurved to middle; with fairly numerous punctures, varying from small to minute. Elytra across middle much wider than prothorax, sides strongly and evenly rounded; with numerous sharply defined punctures of moderate size, shoulders subtuberculate and impunctate. Legs short and stout. Length, 6·0-6·5 mm.

Queensland: Nanango district, in March (H. Hacker). Type, in Queensland Museum; cotype, in South Australian Museum.

A wide species, structurally close to *P. nitidipennis,* but slightly larger, and prothorax and scutellum black. The elytra are more than six times the length of the prothorax, their punctures are numerous but not crowded, from most directions they do not appear to be seriate in arrangement, but from others they do so appear; the series about twice as numerous as on species of other genera of the subfamily.

Oomela nigrivitta, n. sp.

♂. Black and red or flavous-red.

Head with distinct but not dense punctures on and about clypeus, sparse and small elsewhere; clypeal suture curved, a feeble median line joining its middle. Antennae long and thin, no joint transverse. Prothorax at base more than thrice as wide as long; with small, scattered punctures. Elytra very little wider than prothorax at base; with regular rows of small punctures, the interstices impunctate; epipleurae somewhat undulated posteriorly. Apical segment of abdomen triangularly impressed. Length, 3·0-3·5 mm.

♀. Differs in having apical segment of abdomen evenly convex, legs thinner; with basal joint of tarsi smaller.

Queensland: National Park, in November (H. Hacker). Types, in Queensland Museum.

On most of the twelve specimens taken, the pronotum is reddish, with a wide black median vitta (the sides of the vitta gently incurved), and the elytra are black, each with a large, round, reddish spot at the basal third, nearer the suture than side; but on two of them the pronotum appears to be entirely black, although on close examination a faint lessening of colour may be noticed on the sides. The head varies from black to partly or entirely red, the under surface varies from entirely red to part of the apical segment of abdomen and the metasternum (wholly or in part) black; the legs are deep black, with the coxae trochanters and claws reddish. Of the species with two pale spots on elytra, *O. bimaculata* is smaller with prothorax and legs reddish, *O. coccinelloides* has prothorax and legs pale, and the elytral spots transverse, and a variety of *O. elliptica* has reddish legs, and prothorax reddish except for a slight basal infuscation. In the 1917 table of the genus[9] it could be distinguished from *O. bimaculata* and the variety of *O. elliptica* by the median vitta of the pronotum.

Oomela trifasciata, n. sp.

Fig. 5, D.

Red or flavous-red, with black markings.

Head with scattered punctures, and a shallow interocular depression. Antennae rather long and thin, no joint transverse. Prothorax about four times as wide as long; with minute punctures and a few of larger size, but still small,

(9) Lea, *l.c.*, p. 579.

on sides. Elytra very little wider than prothorax at base, sides gently rounded; with regular rows of small punctures, the interstices scarcely visibly punctate. Length, 4 mm.

Queensland: National Park, in November (H. Hacker). Type, in Queensland Museum.

On this and the two following species the claws, from most directions, appear to be simple, and they are drawn backwards so that it is difficult to examine them clearly, but from some directions they are seen to have a fairly large appendix, with a slight notch between the appendix and the rest of the claw; this is more clearly seen on the front tarsi than on the others. Their markings are strikingly at variance from those of all the previously named species of the genus, and it may eventually be considered desirable to propose a new genus for their reception. The elytral epipleurae are more concave than on other species of the genus. The head is black between the eyes, the pronotum is black, except for a median vitta not extending to the base, the sides are usually narrowly reddish, the elytra have three jagged fasciae: one at the basal third (touching the suture to the base), one postmedian (touching the suture from the middle to the apical third), and one subapical (touching the suture to the apex); parts of the under surface and the middle of the femora are black. The sexes differ slightly in the abdomen, the male only having a slight apical depression.

Oomela hieroglyphica, n. sp.

Fig. 5, E.

Head and scutellum reddish, prothorax black, parts of base obscurely reddish, elytra flavous with dark metallic-blue markings, the suture reddish; under surface black, in parts reddish, legs reddish, middle of femora and upper edge of tibiae blackish.

Head with minute punctures; clypeal suture rather deep, its middle dilated into a fairly large fovea. Antennae moderately long, somewhat dilated to apex. Prothorax almost four times as wide as long; with small but sharply defined punctures sparsely scattered about, and very minute ones. Elytra no wider than prothorax at base, but sides gently rounded, and widest at basal third; with regular rows of rather small punctures, the interstices almost impunctate. Length, 4·5 mm.

Queensland: National Park, in November (H. Hacker). Types, in Queensland Museum.

Differs from the preceding species in having the pronotum without a pale median vitta; the zigzag fasciae of the elytra of different shape, the second connected with the first (on one specimen of that species the second is almost connected with the first, but in a different way). The dark markings are very irregular, at the basal third on each elytron of the male there is a mark which at first is directed outwards, and then curves round to touch the base in the middle; just beyond the middle is a very irregular fascia, which is twice dilated and touches the side, from the first dilated part a branch extends obliquely forwards to end on the shoulder; on the inner side joined to the curved subbasal mark and outwardly joined to the margin, near the apex, there is another fascia touching both suture and side. On the female the subbasal and the front part of the postmedian markings are as on the type, but the outer portion of the postmedian marking appears more as an appendage, than part of the fascia itself (with which it is narrowly connected), and the subapical marking is also narrowly connected with the postmedian one. The antennae are dilated to apex but compressed, from positions where the full width is visible it may be seen that the eighth-tenth joints are fully as wide as long, or slightly transverse. The elytral epipleurae are

flavous and rather wide, flattened, but narrowed and wrinkled posteriorly. The male has a smaller and less convex abdomen than the female, with its tip slightly notched.

Oomela picta, n. sp.

Fig. 5, F.

Reddish, flavous, coppery, and dark metallic blue, or green, the elytra trifasciate.

Head with minute punctures; clypeal suture deep and expanded in middle. Antennae moderately long, somewhat dilated to apex, eighth joint about as long as wide, ninth and tenth moderately transverse. Prothorax about four times as wide as long; with small, scattered punctures, and some larger ones on parts of the base. Elytra at base the width of base of prothorax, sides rounded and nowhere parallel; with regular rows of rather small punctures, the interstices impunctate; epipleurae slightly convex, wrinkled posteriorly. Length, 5 mm.

Queensland: Brookfield (H. Hacker). Type (unique), in Queensland Museum.

Differs from the preceding species in the metallic head and prothorax, and large isolated basal spot on each elytron, the fasciae are also all disconnected, except with the suture. The head and prothorax are coppery, with the muzzle red; the elytra are flavous, with a large basal spot on each side, and three wide, irregular fasciae, metallic blue, narrowly edged, in some lights, with brilliant golden-purple, the punctures also, in some lights, are brilliantly metallic; the first fascia terminates at the margin, the second is continued over it to the epipleura, and the third does not touch the margin. It is probable, however, that the markings are variable. The metasternum and part of the abdomen are coppery-green, the rest of the under surface and the legs are reddish, the antennae are black, with the basal joint reddish, and the tip of the eleventh joint obscurely reddish. The sex of the type is doubtful, the abdomen is less convex than is usual on the female, but its tip is simple.

Oomela pictipennis, n. sp.

Flavous with a slight metallic gloss, some parts slightly infuscated or reddish, the elytra with two irregular dark fasciae and two subapical spots; six or seven apical joints of antennae blackish, the rest pale.

Head almost impunctate, clypeal suture deep and dilated in middle, a feeble median line connecting it with base. Antennae moderately long, somewhat dilated to apex, eighth-tenth joints almost as wide as long. Prothorax about four times as wide as long, with rather sparse and small, sharply defined punctures, a few larger ones at extreme base. Elytra with sides subparallel for a short distance, with regular rows of rather small punctures, the interstices impunctate. Length, 4·5 mm.

Queensland: Kuranda, in October (F. P. Dodd). Type (unique), I. 17119.

A beautiful species. The appendix to each claw is larger and more distinct than on the three preceding species, but from some directions, even on this species, the claws appear simple. The middle of the pronotum and the metasternum are darker than the adjacent parts, but they are not deeply infuscated. On the elytra the suture and a basal spot on each side are slightly reddish; there are two irregular brownish fasciae, the first at the basal third, touching the sides (along which it is continued half-way to the base) but not the suture; the second is strongly curved (with the convex side in front) and touches neither the suture nor side, but is connected on the middle of each elytron with the first fascia, and there is a round spot on each side near the apex. As on so many pale species of the subfamily the elytral punctures, from some directions, appear to be much larger than they really are, owing to "waterlogging"; from oblique directions,

however, their true sizes are evident. As the tip of its abdomen is slightly notched the type is evidently a male.

Geomela tropica, n. sp.

Black, elytra with a slight coppery gloss, under surface, legs, antennae, and palpi reddish, femora partly infuscated.

Head with fairly large punctures; clypeal suture curved and dilated on each side. Antennae long and thin, none of the joints transverse, eleventh one-half longer than tenth. Prothorax not quite four times as wide as long, sides evenly rounded; with numerous, but not crowded, punctures of moderate size, becoming somewhat larger and denser on sides, and with rather dense minute ones. Elytra elongate-cordate, base scarcely wider than base of prothorax, sides gently rounded; with regular rows of moderately large punctures, the interstices with minute punctures as on pronotum. Legs moderately long. Length, 5 mm.

North Australia: Adelaide River (H. W. Brown). Type, I. 17103.

An elliptic species about the size of *G. nobilis*, and with similar outlines, but antennae and legs red, and upper surface not at all bluish. The punctures beyond the hind coxae are larger than elsewhere.

Chalcolampra longicornis, n. sp.

Black with a slight bronzy gloss, antennae (the apical half more or less deeply infuscated), palpi and legs castaneo-flavous.

Head with rather dense but somewhat irregular punctures of moderate size, a small fovea near each antenna. Antennae long and thin, no joint transverse. Prothorax about thrice as wide as long; with rather dense and coarse punctures on sides, and a few in middle, and with numerous minute ones. Elytra at base scarcely wider than base of prothorax, sides gently rounded; with regular rows of fairly large punctures, becoming smaller posteriorly; interstices with fairly dense and minute punctures. Claws moderately dilated and subangulate near base. Length, 5 mm.

Western Australia: Perth. Type (unique), I. 4863.

A briefly elliptic, submetallic species, with outlines much as on *C. podagrosa* (from New South Wales) but with longer and thinner antennae, larger and more numerous punctures on pronotum and more numerous and sharply defined ones, although small, on the elytral interstices.

Chalcolampra cribricollis, n. sp.

Dark blackish-blue and finely shagreened, under surface black, antennae and palpi obscurely reddish, legs obscurely diluted with red.

Head with numerous sharply defined punctures of moderate size near eyes, smaller elsewhere; clypeal suture triangular and nonfoveate. Antennae moderately long and not very thin. Prothorax about thrice as wide as long, sides evenly rounded; with crowded punctures of moderate size, not much sparser in middle than on sides, and with minute punctures scattered about. Elytra very little wider than prothorax at base; with regular rows of fairly large punctures, the interstices gently convex and with minute punctures. Apical segment of abdomen subtriangularly depressed in middle. Length, 6 mm.

Tasmania: Mount Wellington (Rev. T. Blackburn). Type (unique), I. 3372.

A dull, dark blue species, with unusually numerous punctures on pronotum. From some directions the claws appear simple, but each has a fairly large basal swelling. The type, judging by the abdomen, appears to be a male.

CHALCOLAMPRA HURSTI Blackb.

Six specimens, from Kangaroo and Flinders Islands (South Australia), appear to belong to this species, but differ from some cotypes (from Queensland) in being slightly more parallel-sided, and with somewhat smaller punctures.

CHALCOLAMPRA GYRÁTA Lea.

A specimen, from Kangaroo Island, differs from the type in being slightly larger, and with the larger punctures on the pronotum slightly sparser and smaller.

Eugastromela, n. gen.

Head small and normally vertical; clypeal suture deep. Eyes lateral, rather small, transverse, with coarse facets. Antennae long, thin, and subfiliform, first joint stout, seventh-eleventh slightly dilated but all longer than wide. Apical joint of maxillary palpi rather long, its tip oblique. Prothorax transverse, apex incurved to middle, sides finely margined. Scutellum small. Elytra not much wider than prothorax, with series of feeble tubercles, and irregular rows of punctures; epipleurae wide. Prosternum with a wide intercoxal process, its sides finely margined, and hind end notched or obtusely bilobed. Metasternum moderately long, middle not simple on male; episterna narrow. Abdomen with first and fifth segments large. Legs moderately long, front coxae transverse; tibiae notched at outer apex for reception of base of tarsi, basal joint of tarsi dilated in male, claws simple. Glabrous, except for antennae and tarsi.

In my table of the genera of Chrysomelides [10] the genus could be associated with *Strumatophyma,* and that is perhaps its nearest ally, but the species of that genus are considerably larger, with the derm rough, and the clypeal suture and palpi different. In the allied genus, *Chalcolampra,* the basal joint of the tarsi (especially the front ones) is often greatly enlarged, and the claws, although not simple, are often rather feebly dentate. I have not broken a specimen, to be sure, but believe all the species to be apterous. I was inclined to consider, from examination of the upper surface only, the six specimens under examination, as belonging to but one species, but, after floating them off, it was evident that there were considerable differences in the metasternum and abdomen, and that the males are abundantly distinct by those parts. They are all deep black, with pale antennae and tarsi, except that on *E. spiniventra* those parts are infuscated. Type of genus, *E. metasternalis.*

Eugastromela metasternalis, n. sp.

♂. Black and shining, antennae, palpi and tarsi flavous, but parts of antennae somewhat infuscated.

Head impunctate; clypeal suture deep, its ends foveate; a narrow impression near each eye, ending in a fovea. Antennae thin, third joint longer than second, eleventh about once and one-half the length of tenth. Prothorax about once and one-half as wide as long, impunctate. Elytra about one-third longer than wide, sides nowhere parallel; with irregular rows of rather large punctures, becoming still more irregular about apex, interstices scarcely visibly punctate, the fourth and sixth with several obtuse tubercles, some of the others with very feeble inequalities. Intercoxal process of prosternum about twice as long as its greatest width (near the front), its posterior end obtusely notched. Metasternum with an obtuse ridge on each side of middle, the two almost meeting at the apex. Basal segment of abdomen about as long as the apical, and each almost as long as the three intermediate ones combined, each of the latter with a row of coarse punctures in middle, giving the surface a subgranulate appearance. Basal joint of front tarsi slightly wider than long. Length, 4 mm.

(10) Lea, *l.c.,* p. 397.

♀. Differs in having the metasternum flat in middle, basal and apical segments of abdomen somewhat smaller (the punctures on the second to fourth are, however, quite as on the type), the tibiae thinner, and the basal joint of tarsi smaller.

Victoria: Melbourne and North Gippsland (H. W. Davey), Emerald (A. H. Elston from C. Jarvis). Type, I. 17125.

On the metasternum of the male the two ridges, as viewed from behind, look like two subapproximate granules; the tip of its abdomen is obliquely flattened, on the female it is evenly convex. The front tibiae of the male, from directly above, is seen to be dilated to apex, and notched there, from the sides its apical third appears narrowed and gently incurved. The specimen from Gippsland has slightly larger but more obtuse tubercles on the elytra than on the type, and the basal joint of each tarsus is slightly larger. On the female there are about ten tubercles on each elytron, and they are more conspicuous than on either of the males.

Eugastromela spiniventra, n. sp.

♂. Black, shining; antennae tarsi and palpi obscurely diluted with red.

Head impunctate; clypeal suture with a small fovea on each side, behind each of which is a small impression. Antennae and prothorax as in preceding species, except that the apical joint of the antennae is somewhat smaller. Elytra subopaque, about once and one-half as long as wide, sides nowhere parallel, with irregular rows of moderately large punctures, the interstices with numerous obtuse tubercles (about thirty on each elytron). Intercoxal process of prosternum with narrow margins, terminated one-third from the front, posteriorly with distinct punctures. Metasternum with two small granules near apex. Basal segment of abdomen opaque, about as long as the three following ones combined, but shorter than apical one, base with a conspicuous median spine, apical segment with median space obliquely flattened, and ending in a large shallow impression. Length, 5 mm.

Tasmania: Waratah (A. M. Lea). Type, I. 17126.

With much more numerous tubercles on the elytra than on the preceding species, and very distinct by the abdominal spine; the small elevations on the metasternum rise suddenly, instead of being the ends of oblique ridges. The intercoxal process of the prosternum differs considerably in its front portion from that of that species, being narrower and without lateral ridges, the tibiae are more dilated to apex and the basal joint of each tarsus is still larger, and longer than wide. The base of the under surface of the head is exposed, and is seen to be transversely strigose for a stridulating apparatus. On the preceding and following species there is no trace of this.

Eugastromela flavitarsis, n. sp.

♀. Black, shining, the elytra subopaque, antennae, palpi and tarsi flavous, trochanters reddish.

Head impunctate; clypeal suture feeble in middle, but foveate on each side, each fovea with an oblique impression connecting it with the side of an eye. Antennae and prothorax as on *E. metasternalis*. Elytra with irregular rows of fairly large punctures, each with about ten very obtuse tubercles. Intercoxal process of prosternum wide and widest at apex, with narrow margins throughout. Apical segment of abdomen slightly shorter than the three preceding combined, and slightly shorter than basal. Length, 4 mm.

Victoria: Beaconsfield, in April (F. E. Wilson); Ararat (H. J. Carter from T. G. Sloane). Type, I. 17127.

Differs from the female of *E. metasternalis* in the abdominal punctures being much smaller, those on the fourth segment are larger than on the other

segments, but they also are quite small, and do not give the surface a granulated appearance, the tibiae are thinner and the claw joint is longer; the elytra also are less shining than on that species. The specimen from Ararat has the elytral tubercles so obtuse that they might fairly be regarded as absent.

PSYLLIODES LUBRICATA Blackb.

This species occurs in abundance on *Solanum nigrum,* and occasionally on other solanaceous plants, in many parts of Eastern Australia, from Mount Tambourine in Queensland, to the Dividing Range, in Victoria. It was described originally from a form with brassy-green elytra and golden pronotum, and such a form is fairly common, but the commonest of all is one having the prothorax and elytra of an almost uniform shade of brassy-green. Many specimens, however, are bluish-green, or blue, or purple, sometimes blue, with the elytra purple; the extent of infuscation of the legs also varies, the hind femora are seldom entirely pale, and are often almost entirely black; the three basal joints of the antennae are pale, and sometimes some of the others, and the joints near the third are never more than slightly infuscated.

Var. **howensis,** n. var. Twenty-two specimens, from Lord Howe Island, have the prothoracic punctures rather denser than on mainland forms, the legs pale, except that the hind femora are black, with a brassy or brassy-green gloss, at least half of the antennae pale, and the following joints but slightly infuscated. The upper surface is usually brassy.

Var. **norfolcensis,** n. var. Numerous specimens, from Norfolk Island, differ from the mainland forms in having the prothoracic punctures smaller and sparser, even on the sides, the three basal joints of antennae flavous, and the others black; the legs are usually castaneous, with the hind femora deeply infuscated or black, but occasionally they are entirely castaneous; the upper surface is nearly always brassy-green. This form may be at once distinguished from the others by the sharply contrasted colours of the third and fourth joints of antennae, in all the other forms the change from a pale to a dark joint being more or less gradual.

Two specimens from Lord Howe Island, in the Australian Museum, have the prothoracic punctures and antennae as on the variety *norfolcensis,* one has the upper surface purple, the other has it black, with a slight bronzy gloss.

Aproida cribrata, n. sp.

Dull flavous; sides of head, of prothorax, and parts of elytra with irregular patches or spots of purplish-brown; prosternum, mesosternum, coxae, trochanters, tarsi, and parts of antennae reddish-brown; ninth and tenth joints of antennae deeply infuscated, eleventh joint flavous.

Head subquadrate, with crowded punctures. Antennae slightly passing scutellum, first joint stout, second small, scarcely half the length of third, the latter about one-fourth longer than fourth, the others gradually decreasing in length, but eleventh longer than tenth. Prothorax slightly transverse, sides gently undulated, angles acute, with an obtuse ridge on each side of middle, and another on each side margin; with crowded punctures much as on head. Scutellum with rather dense punctures; elytra wider than prothorax, sides dilated to beyond middle, and then narrowed to apex, where each is produced in a stout spine; base sinuous; each with an obtuse ridge on the outer side of the fourth row of punctures; with rows of very large punctures or small foveae. Under surface with crowded punctures on prosternum and on sides of head, elsewhere with small and sparse ones. Legs short, femora edentate. Length, 5·5 mm.

Queensland: National Park (H. Hacker). Type (unique), in Queensland Museum.

A much smaller and decidedly rougher species than *A. balyi,* with a shorter head, paler antennae, only one terminal joint pale, femora unarmed, etc. Probably in life the parts are greenish that are now flavous; on each elytron the dark parts are: a spot about scutellum, an antemedian spot nearer the side than suture, and a postmedian vitta extending to the apex of the apical spine; there are also several less defined spots.

MONOLEPTA FROGGATTI Blackb., ♀, 1891.
M. pictifrons Blackb., ♂, 1896.

This species was described originally as from Ballarat. A female in the South Australian Museum is marked as a cotype, and agrees with the description, except that the scutellum is black, and that the sides of the elytra are infuscated (no doubt overlooked). Mr. F. Erasmus Wilson and I recently obtained, on the Upper Williams River, in New South Wales, numerous specimens that probably belong to the species; the females agree well with the cotype, except that the dark parts of the elytra are more intensely black, and the sutural marking less extended; they vary, however, in the abdomen; many of them have this entirely dark (as on the cotype), and others have it entirely pale; still others have two dark spots on each of the intermediate segments. The male (Mr. Wilson obtained a pair, still fast *in cop.)* differs in being smaller and with the elytra entirely deep black; on some specimens, in certain lights, however, they appear to be darker about the suture than elsewhere. Similar specimens were previously commented upon as probably belonging to *M. pictifrons.*[11] Two cotypes of *pictifrons* in the Museum are males, and have the elytra blackish, with the sutural region intensely black; they were from "Victoria," and, I am now convinced, are males of *M. froggatti.* I know of no other species in the genus in which the sexes differ so much.

EROTYLIDAE.

Isolanguria, n. gen.

Head obtusely subtriangular, a swelling behind each eye; clypeal sutures indistinct except at sides, not conspicuously distinct from labrum. Eyes small, lateral, moderately faceted. Antennae short, club three-jointed. Palpi small. Prothorax elongate, sides and base narrowly margined. Scutellum small and strongly transverse. Elytra long, thin, and almost parallel-sided. Prosternum with intercoxal process rather narrow, its apex truncate, and a fine ridge on each side; coxal cavities open. Metasternum elongate, episterna thin, epimera minute. Abdomen with first segment about one-fourth longer than second, the others gradually decreasing in length, coxal lines not distinct. Legs short, femora stout, tibiae with a short apical spine, tarsi with three basal joints densely clothed on lower surface, fourth joint scarcely visible, claw joint long and thin.

The type of the genus is a thin, flat, brown species, which evidently belongs to the Languriides. The tarsi are densely clothed, and have rather short setae at the sides, so that Fowler would probably have referred the genus to his first main division of the subfamily,[12] placed there as the coxal lines are not in evidence; and as the head is symmetrical in both sexes (the swelling behind each eye seems to be a very unusual feature in the subfamily), femora unarmed, club of antennae longer than broad, elytra rounded at apex, and eyes not coarsely faceted, it could be associated with *Perilanguria* (the description of this genus is very unsatisfactory, but the characters noted in the table appear to be useful, *P. monticola* is noted as the type of the genus, and was described as having the club four-jointed, etc.). Regarding it as belonging to his second division it cannot be traced

(11) Lea, Proc. Linn. Soc. N.S. Wales, 1923, p. 525.

(12) Fowler, in Wytsman's Genera Insectorum, Fasc., 78.

beyond the genera 34-36, from *Penolanguria* it is distinguished by its elongate form, and from *Ischnolanguria* and *Languria* (in the table *Languria* is noted as having the club five or six jointed), by its three-jointed club, it does not appear, however, to be very close to any of the genera figured by Fowler. The front coxal cavities appear to be closed behind by a thin flap, but from some directions a fine projection from each coxa may be seen extending alongside the intercoxal process to the apex, where it slightly overlaps the flap; on dissection this is easily ruptured, when the cavity appears to be widely open.

Isolanguria fusca, n. sp.

Dark castaneous, elytra abdomen and basal joints of antennae somewhat paler, legs castaneo-flavous. Upper surface glabrous, under surface finely pubescent, a short fringe at apex of prosternum and a thin fascicle on each side of apex of abdomen.

Head gently convex; with rather dense and sharply defined but not very large punctures. Antennae not extending to front coxae, first joint stout, third distinctly longer than second or fourth, fourth to eighth small and subglobular, ninth longer and about twice as wide as eighth, the size of tenth and smaller than eleventh. Prothorax longer than wide, sides dilated at apex, obliquely narrowed to near base, base somewhat sinuous, a shallow fovea on each side of it, and a smaller one on each side at basal third; punctures much as on head, but with an impunctate median line. Elytra not as wide as widest part of prothorax, with rows of fairly large punctures, becoming small posteriorly, interstices with sparse punctures. Prosternum with rather large punctures on flanks, smaller and more or less transversely confluent elsewhere. Metasternum with punctures as on head. Abdomen with somewhat smaller and denser punctures, apical segment slightly concave, its tip obtusely produced. Hind femora scarcely extending to middle of second abdominal segment. Length, 7 mm.

Lord Howe Island (A. M. Lea). Type, I. 11780.

Three specimens were beaten from recently felled shrubs; one (probably a male) has the prothorax more dilated in front than the others.

COCCINELLIDAE.

Rhizobius erythrogaster, n. sp.

Black, muzzle, antennae, palpi, abdomen, and parts of legs more or less reddish. Moderately densely clothed with rather long and waved, whitish pubescence, mixed with rather long, erect, dark setae; under surface and legs more sparsely clothed.

Head with fairly dense but inconspicuous punctures. Prothorax with rather dense punctures, more distinct on sides than in middle; front angles produced and rounded off. Elytra with dense and, except where obscured by pubescence, sharply defined punctures. Abdomen with fairly dense punctures, tips of lamellae almost touching apex of first segment. Prosternum with a fine carina on each side of the median process. Length, 2·2-3·0 mm.

Norfolk Island (A. M. Lea). Type, I. 11661.

A rather strongly convex species, with the red abdomen of *R. ventralis*, and in general resembling that species, but consistently much smaller, pubescence longer and more waved, and mixed with moderately long, erect, dark setae (much more numerous and distinct than on that species). In Blackburn's table of *Rhizobius*[13] it could be associated with that species. Some specimens have a

(13) Blackb., Trans. Roy. Soc. S. Austr., 1892, pp. 257-9.

slight metallic gloss, but on most of them the upper surface is a deep shining black; the metasternum is usually deep black, in strong contrast with the abdomen, but is occasionally of a dingy reddish brown, the trochanters and tarsi are always pale, the tibiae are usually paler than the femora, the head is more or less obscurely diluted with red from the middle to the front, sometimes almost to the base, the front of the prothorax is sometimes very narrowly reddish. Twenty-nine specimens were obtained.

Rhizobius viridipennis, n. sp.

Head, prothorax, antennae, palpi, legs, and part of abdomen more or less dingy red, elytra dark metallic green, mesosternum, metasternum, and basal parts of abdomen black or infuscated. Moderately densely clothed with whitish or slightly golden pubescence, interspersed with numerous suberect, but not very long, dark setae.

Head with fairly dense and sharply defined punctures at base, becoming smaller in front. Prothorax more than thrice as wide as long, sides strongly rounded in front; with rather dense punctures, becoming crowded on sides. Elytra with dense, even, sharply defined punctures. Abdomen with lamellae terminated about one-fourth from apex of basal segment. Prosternum with a fine carina on each side of the median space. Length, 2·5-3·0 mm.

Lord Howe Island (A. M. Lea). Type, I. 11664.

In general appearance close to some specimens of *R. hirtellus*, but the average size smaller, sides of prothorax more rounded in front, upright setae less numerous and much shorter, and elytral punctures larger and more sharply defined. The elytra are decidedly green on most of the specimens, but on a few are more or less bronzy or obscurely purple; the red of the head and prothorax is usually uniform, although never bright, but on some specimens the disc of the latter is obscurely infuscated, and on two of them the infuscation extends almost to the sides; the extent of infuscation of the basal part of the abdomen varies; on some specimens the femora are also infuscated. Thirteen specimens were obtained, including two from tree-ferns on Mount Ledgbird.

Rhizobius filicis, n. sp.

Black, muzzle, antennae, palpi, tip of abdomen and parts of legs more or less reddish. Moderately densely and uniformly clothed with whitish pubescence.

Head and prothorax with punctures as on preceding species; elytra with rather denser ones, becoming very small near suture. Lamellae of abdomen extending to about one-fourth from tip of basal segment. Length, 2·5-2·7 mm.

Lord Howe Island (A. M. Lea). Type, I. 11665.

The general outlines are much as on the preceding species, but the colours and clothing are very different, the punctures near the suture are much smaller, and the median space of the prosternum is more triangular, with less conspicuous carinae. In Blackburn's table the species would probably be associated with *R. lindi* and *R. dorsalis*, to both of which it has a general resemblance; from the former it differs in being not at all metallic, elytra with somewhat larger punctures and without a fringe of longer hairs (on most specimens of *lindi* the longer hairs or setae, of the upper surface, appear to form a quite conspicuous lateral fringe); from *dorsalis* it differs also in the elytral punctures and clothing. The tarsi and palpi are almost flavous, the tibiae and trochanters are usually paler than the femora. Most of the specimens have entirely black elytra, but on several the elytra, except for the sides and suture, are of a dingy reddish-brown; on such specimens the dull red portion of the abdomen extends along the sides almost to the base. Twenty-three specimens were beaten from ferns on the summit of Mount Gower.

Scymnus rostratus, n. sp.

Dark castaneous-brown, prothorax, sides excepted, almost black, tarsi almost flavous. Upper surface with numerous, but not dense, suberect, reddish setae.

Head subtriangular, with fairly distinct punctures. Prothorax more than thrice as wide as long, with small punctures. Elytra evenly and rather strongly convex; with dense, sharply defined punctures. Under surface with punctures as on elytra, but less dense. Length, ·9-1·0 mm.

Lord Howe Island (A. M. Lea). Type, I. 11662.

From the sides the muzzle seems to be produced as on some species of Pythidae, and under a compound power the eyes seem rather coarsely faceted, and the suture between the two first abdominal segments to be distinct, so it is possible the species should not have been referred to *Scymnus*, but to a new genus. I was not able to manipulate the hind legs so as to expose the abdominal lamellae. Three specimens were obtained, and the average of these is slightly smaller than the average of *S. vagans*, but the two species are very different in their clothing, punctures, muzzle, etc. One of the specimens is much darker than the others.

Scymnus macrops, n. sp.

Castaneous-brown, some parts darker, antennae, palpi, tibiae, tarsi and elytral epipleurae more or less flavous. Clothed with short, whitish pubescence, somewhat longer and less depressed on upper surface than on under.

Head smooth, with fairly dense and rather small but distinct punctures. Eyes larger than usual. Prothorax about four times as wide as long, sides rather strongly rounded, punctures slightly denser than on head, but less distinct. Elytra with punctures as on head. Abdomen with sutures obliterated in middle, lamellae touching tip of basal segment for most of their width. Length, 2·0-2·2 mm.

Lord Howe Island (A. M. Lea). Type, I. 11666.

The size and outlines are much as those of *S. auruginеus*, but the elytra, except that the suture and base are very narrowly darker, are uniformly coloured throughout, and have somewhat longer pubescence; it is rather larger and more oblong than *S. australis*, less brightly coloured, clothing longer and eyes larger; from *S. inaffectatus*, to which perhaps it is closest, it differs in being slightly more oblong and the eyes somewhat larger and closer together. The under surface, except the sides of the prosternum and sometimes the tip of the abdomen, and scutellum are black or piceous-brown, and the femora are deeply infuscated. Five specimens were obtained, and of these three have the head slightly paler than the prothorax, and two have it slightly darker; the difference is probably sexual.

Scymnus obscuripennis, n. sp.

Black or piceous-brown, elytra obscurely paler; muzzle, antennae, palpi, and legs flavous. Rather densely clothed with subdepressed, ashen or whitish pubescence.

Elliptic-ovate, rather strongly convex, punctures of elytra fairly dense and distinct, elsewhere sparser and less distinct. Abdomen with suture between two basal segments feeble in middle, lamellae extending to about one-third from apex of basal segment. Length, 1·2-1·5 mm.

Norfolk Island (A. M. Lea). Type, I. 11761.

About the size of *S. vagans*, but with longer clothing, elytra paler, and legs entirely flavous. On specimens with the prothorax black the elytra are of a dingy reddish-brown, those with the prothorax piceous-brown have the elytra somewhat

paler, but they are never of a bright red, the flavous portion of the head varies in extent, probably sexually. Eleven specimens were obtained.

Scymnus variiceps, n. sp.

♂. Black or blackish, head, front angles of prothorax, antennae, palpi, and tarsi more or less reddish. Densely clothed with short, depressed, uniform, ashen pubescence.

Head rather wide, with small, dense punctures. Prothorax more than thrice as wide as long, punctures much as on head. Elytra with very dense punctures, slightly more distinct than on head. Abdomen with six segments, lamellae large, and touching apex of first segment for most of their width. Length, 2·5-3·5 mm.

♀. Differs in having the head dark, except for the flavous muzzle, and the prothorax without a pale spot in each front angle.

Lord Howe Island (A. M. Lea). Type, I. 11762.

A depressed species, with antennae somewhat longer than the space between the eyes, and with the suture between the two basal segments of abdomen fairly distinct in the middle, characters somewhat at variance with *Scymnus,* but as the eyes are finely faceted, elytral epipleurae not foveate, and mesosternum not longitudinally carinate, it was considered desirable to refer the species to that genus, rather than to *Bucolus,* or to a new one; its outlines are much as those of *Rhizobius aurantii.* The tibiae and trochanters are sometimes almost as pale as the tarsi, the abdomen is usually slightly paler than the metasternum, but is not strongly contrasted with it. On several specimens of each sex the extreme front margin of the prothorax is pale. Eighteen specimens were taken, mostly on the fruit of a *Pandanus,* where they were eating a white scale insect, *Aspidiotus,* sp.

SCYMNUS FLAVIFRONS Blackb., var. **norfolcensis,** n. var.

Numerous specimens taken on Norfolk Island appear to belong to *S. flavifrons,* but differ from the typical form in being slightly more oblong, and with rather more distinct punctures. The sexes differ much as do those of the typical form, except that, on the twenty-four males taken, the pale sides of the prothorax are never narrowly connected across the apex. The elytra are either entirely black, or with the tips obscurely diluted with red.

A UNIQUE EXAMPLE OF ABORIGINAL ROCK CARVING AT PANARAMITEE NORTH.

By C. P. Mountford.

[Read August 8, 1929.]

Plate X.

This paper records the finding of a unique example of aboriginal art situated adjacent to a group of carvings called Panaramitee North (1). Long. 139, 38′ E; Lat. 32, 34′ S.

The latter were investigated by me in 1926, but this remarkable design was missed owing to the fact that it was carved on an isolated outcrop of slate which projected only a few inches above the level of the surrounding saltbush plain. This rock was about 100 yards east of the main group.

Previous to my visiting this district during the Christmas vacation of 1928, Mr. N. Tindale allowed me to examine a photograph of this carving taken by Mr. Bartlett. That gentleman described the position as: "Four miles north of the Panaramitee Station and 200 yards from the creek on a saltbush plain."

At the completion of other investigations in the district, a search was made for this example. It was (as mentioned before) located close to one of my previous finds.

As the time available was extremely limited on this occasion, only a rough tracing and photograph were taken.

During Easter of 1929 a special trip was made to obtain a plaster of paris mould of the whole rock surface. This was subsequently presented to the South Australian Museum authorities, who have since produced a replica of the original rock surface from this mould.

Description.

The design was engraved on an outcrop of slate, approximately oval in form, about 5 feet 6 inches major diameter and 2 feet 9 inches minor diameter. The intaglios which are shown in fig. 1 were well cut, the black parts of the drawing indicating where the rock surface had been removed by the usual process of chipping with pointed flints (1).

A portion of the rock on which the design was carved had weathered away, and an attempt has been made to reconstruct the pattern by means of the dotted lines on fig. 3.

A close examination of the rock surface revealed several interesting features:—

(1) That the rock surface has been engraved in two distinctly different periods. On text fig. 1 are shown all the designs engraved on the rock surface. Fig. 3 indicates what is considered to be the original design when the more recent carvings are deleted. In text fig. 2 the later carvings are drawn. These are deeper, revealing little signs of erosion which were evident on the original.

An examination of pl. x. will clearly indicate the more recent work.

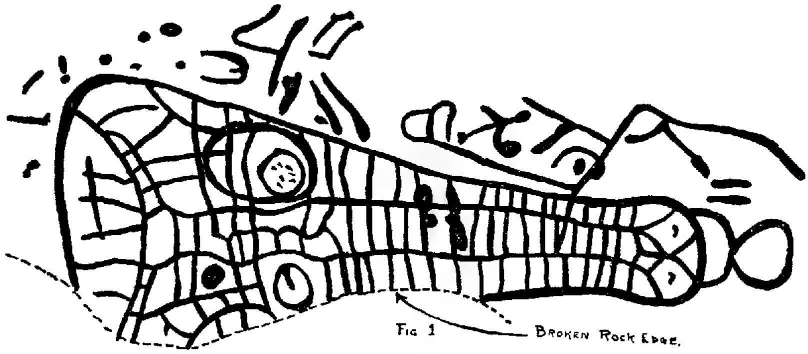


Fig 1

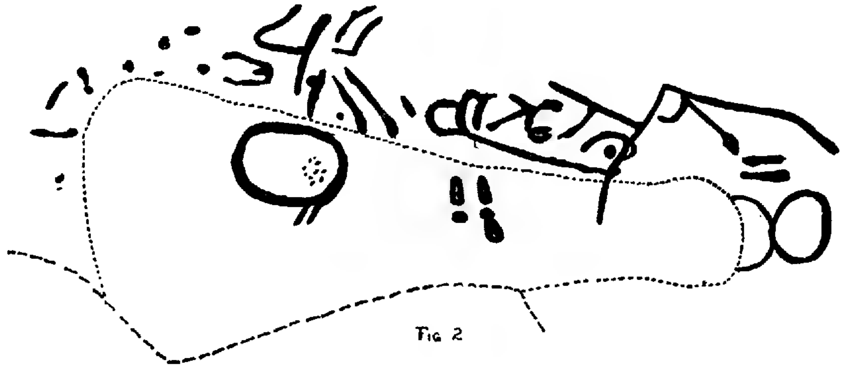


Fig 2

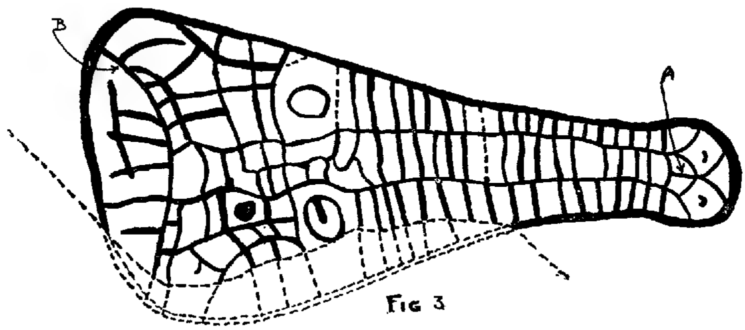


Fig 3

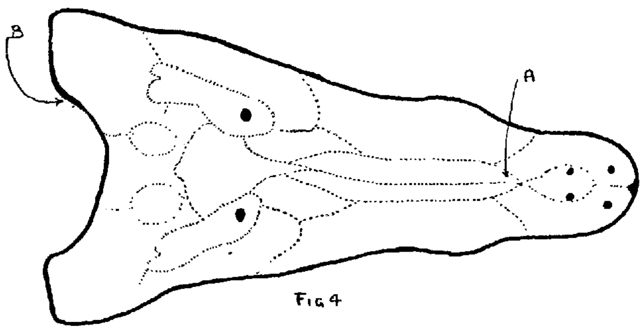


Fig 4

(2) That the design bears a striking resemblance to the head of *Crocodilus porosus.*

Fig. 4 is an outline of drawing *C. porosus* (after Parker and Haswell), drawn to the same scale as fig. 3. The sutures of the skull and the orbit and the nasal openings are shown in dotted lines.

An examination of figs. 3 and 4 discloses several points of resemblance.

(a) The general outline and the placing of the eyes and nostrils are similar.

(b) The lines in the carvings at A, fig. 3 (although somewhat out of position), resemble the lines of sutures in the skull at A, fig. 4.

(c) Again, at B. fig. 3, the line seems to indicate the base of the skull as indicated at B, fig. 4.

Further comparison of the two drawings displays several points of similarity relating to the sutures. In fact, there is so strong a relation between the two drawings that one almost precludes the possibility of the carving representing anything else but this saurian.

Age of the Design.

The fact that fossil crocodile remains have been found in South Australia, and a number of native legends speak of mythical monsters who are associated with water and devour people, leads me to suggest that this carving was executed at a time when the crocodile was alive in this area.

Professor J. W. Gregory (7) mentions that in native legends of the Lake Eyre district which relate to the Kadimakara (or mythical monsters), two distinct animals are referred to:—

> One lives in pools and attacks people who go near them. Stories of this type may be based on the crocodile, for that this saurian once swarmed the rivers of Lake Eyre is shown by the abundance of their fossil remains collected.
>
> The second type of Kadimakara was a heavy land animal with a single horn on its forehead. This description suggests the diprotodon, which was provided with a large projection of the nasal bones.

The same writer, although satisfied that the native legends refer to the crocodile and diprotodon, does not assign any great antiquity to man in Australia.

Dr. H. Basedow (2) draws attention to intaglios found at Wilkindinna and Yunta, which he suggests may have been produced by the natives to represent the footprints of the extinct diprotodon.

Hale and Tindale (10) also record a native legend with the photograph already referred to. This story was obtained by Mr. Harris (11) from the Wilpena district, and speaks of a mythical being called Kaddikra (evidently the same as Gregory's Kadimakara) which ravaged the country and devoured every living thing that came its way.

This monster was associated with water in the legend and was, in all probability the crocodile.

Spencer and Gillen (6) record a traditional story from Central Australia in which the aborigines speak of the time when the country was covered with salt water, which was gradually withdrawn toward the north, as the people of that country wanted to get it and keep it for themselves.

Mr. H. Y. L. Brown (3) records the finding of crocodilian remains on Warburton and Diamentina Rivers in 1892, and Mr. R. Etheridge, jun. (5) describes these remains as those of crocodiles, and suggests their geological age as being

Tertiary or Post-Tertiary. The finds made by Mr. Brown are exhibited in the South Australian Museum.

Summarising, then, we have:—

(a) That the crocodile was alive in South Australia in Pleistocene times.

(b) That native legends refer to a creature resembling a crocodile.

(c) Man is known to have lived in other parts of the world during the Pleistocene, and there is no evidence to show he did not exist on this continent during that time.

(d) Records do not show that the natives of this area ever visited the present habitat of the crocodile; in fact, the aborigine rarely travels beyond the borders of his own tribal area. According to Etheridge (5) the *Crocodilus porosus* is not known to extend further south than the Boyne River, Port Curtis, Central Queensland.

(e) It is hardly possible that the native would have carved a design having so many points of resemblance to this saurian if he had not have known it intimately.

Therefore, the balance of evidence suggests that the aborigine was contemporary with the crocodile in South Australia and that this carving was executed during that period, that is, Pleistocene times.

If so, then we have a very definite link in the somewhat meagre chain concerning the antiquity of man in Australia.

LITERATURE.

(1) MOUNTFORD—Aust. Assoc. Adv. Sc., 1928, pp. 337-366.

(2) BASEDOW—Journ. Roy. Anthrop. Inst. Gt. Brit., 1914; pp. 195-211.

(3) BROWN—South Australia, Parliamentary Papers, No. 141, 1892.

(5) ETHERIDGE, JUN.—South Australia, Parliamentary Papers, No. 25, 1894.

(6) SPENCER AND GILLEN—"Native Tribes of Central Australia," p. 388.

(7) GREGORY—"The Dead Heart of Australia," p. 230.

(9) HALE AND TINDALE—Records S. Aus. Museum, vol. iii., No. 1, 1925, pp. 52-57.

(10) HALE AND TINDALE—S. Aust. Naturalist, vol. x., No. 2, p. 30.

(11) HARRIS—Public Service Review, 1903, pp. 21 22.

MAGMATIC DIFFERENTIATION AT MANNUM, SOUTH AUSTRALIA.

By A. R. Alderman, M.Sc.

[Read August 8, 1929.]

The object of this paper is an attempt to show the relationship between what appeared to be an acidic and a basic phase of the granite which occurs at Mannum, in South Australia.

The rocks, here described, occur on the eastern bank of the River Murray, at Section 156 in the Hundred of Younghusband. B. F. Goode(1) has published a petrographic description of the Mannum granite, which is quarried extensively in this locality.

The outcrop of granite is only a small one, and it occurs as an inlier amid the surrounding plains of fossiliferous Tertiary and Recent deposits. Goode describes it as "a narrow strip of granite, about three-eights of a mile in length, with a maximum width of nearly a hundred yards."

The granite itself is of a pink colour, and is coarsely even-grained. The pink colour is due to the preponderance of flesh-coloured orthoclase felspar, which, with smoky quartz and scattered flakes of biotite mica, constitute the essential minerals of the rock.

Cutting across the main outcrop of granite in a S.E.-N.W. direction may be seen a number of dykes of a rock of aplitic facies. The width of these dykes varies from about an inch up to about three feet. These aplitic dykes occur, for the most part, at the northern end of the granite outcrop.

Further south than this, and running in a direction parallel to the above-mentioned aplitic dykes, occurs a dyke of dark basic rock. This is approximately two feet wide, and crosses the granite outcrop from side to side.

It is quite evident from the structure and nature of all these dykes, that they were formed subsequently to the solidification of the granite.

This paper gives the results of an attempt by the writer to discover what relationship these dyke-rocks bear to the normal granite of the area. From a superficial survey of the occurrence, it would appear that the rock of aplitic facies and the basic rock were probably representative of an acidic and a basic phase respectively, which was formed by the differentiation, at great depth, of a magma, which is now represented by the normal Mannum granite.

Petrographical examinations were made of both of these dyke-rocks.

Petrographic Description of the Aplitic Rock.

Macroscopic Features.

A fine-grained holocrystalline rock of a brownish pink colour. The grain-size is very even, except for a few scattered individuals, which are rather larger than the majority. Minerals distinguishable in the hand-specimen are felspar, quartz and biotite. The felspar is the most prominent mineral present, and being flesh-coloured, gives to the rock a pink tinge. The quartz has a vitreous lustre and the larger individuals have a dark smoky appearance. The biotite is present only in very small flakes, which are black, and are distributed throughout the rock in a very even manner. None of these minerals show idiomorphic outlines in the hand-specimen.

Microscopic Features.

A holocrystalline fine-grained rock. The average diameter of the grains, which is very constant in the sections examined, is about 0·3 mm. The rock

(1) B. F. Goode, "The Mannum Granite," Trans. Roy. Soc. S. Austr., vol. li., 1927, p. 126.

texture is allotriomorphic granular. No trace of fluidal arrangement of the minerals is noticeable.

The minerals present are the following:—

Felspar.—This group is represented by three distinct forms, including both plagioclase and potash varieties.

The *plagioclase* is in excess of the other varieties, and is very often clouded by dusty decomposition products. The maximum extinction angles observed on a plane normal to 010 give the composition as Ab_{80} An_{20}, or a normal oligoclase. The refractive index is slightly higher than that of Canada Balsam. The twinning in the sections examined is almost entirely on the Albite law, Carlsbad twins being extremely rare. Occasional graphic intergrowths with quartz may be seen.

An interesting point is the unusual alteration which some of the plagioclase seems to have undergone. In several cases may be seen a zone of clear plagioclase surrounding an aggregation of some colourless mineral of high refractive index. This mineral, which occupies the inner zone, strongly resembles calcite in its birefringence and refractive index. A resemblance to cancrinite was also shown, but this idea was discarded owing to the very low refractive index of cancrinite. Microchemical methods were applied, and the mineral in question was found to give off bubbles of gas (supposedly carbon dioxide) on being treated with hydrochloric acid. A small amount of stain (malachite green) was also absorbed by the mineral. Taking into account its properties, both optical and chemical, and its relation to the surrounding plagioclase, the probability is that it is an aggregate of calcite and kaolinitic material formed by the alteration of an inner, more calcic, zone of basic plagioclase. As the crystallisation of the rock progressed, an outer zone of more sodic, acid plagioclase was formed, which did not suffer the same decomposition.

Microcline is, for the most part, clear and undecomposed. It shows the usual cross-hatching due to twinning on both the Albite and Pericline laws. The twin lamellae, as is usual in microcline, are irregular and spindle-shaped. Judging by the chemical composition of the rock, the writer was led to suspect that the microcline was a soda variety. Reference was made to certain standard works on mineralogy, and the writer was very surprised at the lack of information concerning methods by which the soda varieties of microcline may be distinguished from the potash varieties in a rock section. The only point which is commonly mentioned concerns the comparative thinness of the twin lamellae in the soda varieties, and this could hardly be called a satisfactory test. H. A. Alling, in his work on "The Mineralogy of the Feldspars,"(2) comments on the paucity of information on the subject. Alling's tests are not readily applicable to work on thin sections, and apart from the fact that the soda content of the potash felspars is mostly a good deal higher than is generally recognised, very little information could be obtained on the subject.

The microcline occurring in this rock varies in the thickness of the twin lamellae from one individual crystal to another. The refractive index is slightly lower than that of Canada Balsam.

Normal *orthoclase* is present, but to a far less extent than the felspars already mentioned. Some of the individual crystals are very much decomposed to a dusty aggregate, which renders them hard to distinguish from plagioclase. Occasional Carlsbad twins occur, and rarely a micrographic intergrowth of orthoclase and quartz may be observed.

Quartz occurs in clear, colourless, anhedral grains with very few inclusions. It is present in great quantity, being second only to felspar in order of magnitude. A somewhat shadowy extinction, due to strain, may often be noticed in the quartz.

(2) Journ. Geol., xxix., 1921, and xxxi., 1923.

Biotite is plentifully distributed throughout the rock in small flakes only. It is often associated with apatite and magnetite, which are frequently included in the biotite. The pleochroism of the biotite is from pale brown to a darker greenish brown. In some sections this mineral has undergone a slight amount of change to chlorite, which is of a pale green colour and pleochroic. Only rarely were pleochroic haloes observed in the biotite. They then occurred surrounding a minute crystal of colourless zircon. The biotite was apparently one of the first minerals to crystallise.

Primary *muscovite* mica is not as plentiful as biotite, and in contrast to that mineral occurs only very irregularly. Secondary *sericitic mica* occurs as an alteration product of felspar.

Calcite occurs both as an interstitial mineral and also in connection with the decomposition of the calcic felspars.

Titaniferous iron ore, which is black and opaque, occurs irregularly throughout the section. A certain amount of white *leucoxene* is associated with it.

Sphene is present in occasional irregular masses, and sometimes shows the wedge-shaped outlines typical of the mineral. In colour it is greyish-brown, and displays a feeble pleochroism. It has undergone marked decomposition to a brownish amorphous material.

Apatite is not plentiful, but very small rod-like forms occur, and occasionally larger anhedral masses, often associated with the opaque iron ore.

Zircon occurs in small quantity, sometimes showing euhedral outlines. It also occurs in the biotite, surrounded by a pleochroic halo.

A chemical analysis of this rock was made by the writer, the results of which are given below.

CHEMICAL COMPOSITION OF THE APLITIC ROCK.

	Per cent.		Per cent.
Silica (SiO_2)	73·49	Carbon dioxide (CO_2) ..	Trace
Alumina (Al_2O_3)	14·14	Titanium dioxide (TiO_2) ..	0·25
Ferric oxide (Fe_2O_3) ..	1·26	Zirconium dioxide (ZrO_2) ..	Trace
Ferrous oxide (FeO) ..	0·69	Phosphorus pentoxide (P_2O_5)	0·11
Magnesia (MgO)	0·44	Sulphur (S)	0·05
Calcium oxide (CaO) ..	1·60	Chromic oxide (Cr_2O_3) ..	None
Soda (Na_2O)	3·75	Manganous oxide (MnO) ..	0·02
Potash (K_2O)	3·67	Barium oxide (BaO)	None
Water (combined) (H_2O+)	0·34		
Water (hygroscopic) (H_2O-)	0·13	Total	99·94

The specific gravity is 2·70.

THE NORM.

	Percentage.		
Quartz	34·08	Q = 34·08	Salic Group = 95·76%
Orthoclase	21·68		
Albite	31·44	F = 60·35	
Anorthite	7·23		
Corundum	1·33	C = 1·33	
Enstatite (hypersthene) ..	1·10	P = 1·10	Femic Group = 3·37%
Ilmenite	0·46		
Magnetite	0·91	M = 1·69	
Haematite	0·32		
Pyrite	0·24		
Apatite	0·34	A = 0·58	
Water	0·47		

In the C.I.P.W. classification the position of the rock is, therefore:—

I., 4, 2, 3.

The magmatic name is *Toscanose*.

Discussion of the Analysis.

This analysis shows several points of interest when compared with Goode's analysis of the granite. Silica and lime are distinctly higher than in the granite, and magnesia slightly so. Soda is practically the same in both analyses, iron is about one per cent. lower. However, the greatest point of difference is in the potash content, which in the aplitic rock is nearly two per cent. less than in the granite. In the following table the above analysis may be compared with that of the Mannum granite, and also with several well-known granites occurring within a comparatively short distance of Mannum. Also given is the composition of a tonalite situated half-way between Mannum and Palmer. The outcrops of this tonalite occur nearer to the Mannum granite quarries than any other known igneous rock in the district. A point of interest is the similarity in composition of the aplitic rock with the granites quoted from Palmer, Swanport and Monarto:—

	A.	B.	C.	D.	E.	F.
SiO_2	73·49	70·77	73·96	72·42	74·20	63·88
Al_2O_3	14·14	13·69	13·67	15·49	14·53	16·37
Fe_2O_3	1·26	1·97	1·22	0·44	1·14	1·99
FeO	0·69	0·97	1·03	1·03	0·90	2·96
MgO	0·44	0·34	0·56	0·20	0·20	2·24
CaO	1·60	0·94	1·56	1·44	1·00	5·18
Na_2O	3·75	3·70	3·01	4·30	3·06	3·66
K_2O	3·67	5·68	3·36	3·78	3·55	1·61
H_2O+	0·34	0·45	0·04	0·12	0·15	0·45
H_2O-	0·13	0·36	0·29	0·18	0·15	0·21
CO_2	Trace	—	0·22	0·04	0·11	None
TiO_2	0·25	0·72	0·37	0·22	0·29	0·86
P_2O_5	0·11	0·11	0·16	0·19	0·08	0·23
Other constit. ..	0·07	0·45	0·31	0·13	0·16	0·07
Total ..	99·94	100·15	99·76	99·98	99·52	99·71

A. Aplitic rock, Mannum. Anal., A. R. Alderman.

B. Granite, Mannum. Anal., B. F. Goode (Trans. Roy. Soc. S. Austr., vol. li., 1927, p. 127).

C. Granite, Palmer. Anal., W. S. Chapman (Geol. Surv. S. Austr., bull. 10, 1923, p. 68).

D. Granite, Monarto. Anal., W. S. Chapman (Geol. Surv. S. Austr., bull. 10, 1923, p. 68).

E. Granite, Swanport. Anal., W. S. Chapman (Geol. Surv. S. Austr., bull. 10, 1923, p. 68).

F. Tonalite, near Mannum. Anal., A. R. Alderman (Trans. Roy. Soc. S. Austr., vol. li., 1927, p. 21).

Petrographic Description of the Basic Rock.

Macroscopic Features.

Examined in the hand-specimen, this rock is very dark in colour, heavy, and finely holocrystalline. Except for a few larger rectangular crystals of felspar of porphyritic habit, the rock is even-grained. Minerals distinguishable in the hand-specimen are:—(1) Felspar in long lath-like forms, and occasional larger crystals which show a rectangular outline. These are colourless, with a somewhat opalescent appearance. (2) A black ferromagnesian mineral, apparently hornblende. (3) Black flakes of biotite mica; this being but rarely seen. (4) Brass-yellow specks of pyrites.

From the appearance, structure, and the apparent degree of basicity, as judged in the hand-specimen, the rock would probably be classed as a lamprophyre.

Microscopic Features.

In thin section, this rock is seen to consist essentially of plagioclase and green hornblende, with smaller amounts of biotite and iron ore. No trace of fluidal arrangement is evident, although the lath-like form of the felspar crystals would be particularly adapted to the preservation of such structure. The rock is holocrystalline, and owing to the fact that the crystallisation of some of the felspar has preceded that of the remainder of the rock, a texture is produced in which subhedral felspars occur in an allotriomorphic granular base. The average diameter of the grains in the groundmass is about ·25 mm. The large felspars are, however, considerably larger than this; the largest one seen in the hand-specimen measured nearly a centimetre along its longest axis.

The minerals present are the following:—

Plagioclase, both in large subhedral crystals and in smaller lath-like anhedrons. The composition of the plagioclase is different in these two classes. Determinations were made by means of the maximum extinction angles observed on a plane normal to 010. The large porphyritic crystals gave a composition of Ab_{35} An_{65}, which is a fairly basic labradorite. The smaller felspars of the groundmass gave a composition equivalent to Ab_{48} An_{52}, which is an acid labradorite. This decrease in basicity from the earlier crystallising plagioclase to that which crystallised later, is what would be expected. Carlsbad twins are quite common, in addition to the usual Albite twinning. The refractive index of all the felspar is higher than that of Canada Balsam. The effects of strain are shown by the development of "secondary twinning."

After the felspar, primary *hornblende* is the most important mineral. When viewed in ordinary light it is pale green in colour. In polarised light it shows a strong pleochroism, the colour varying from pale brown to dark green. It contains numerous minute inclusions of magnetite, often arranged parallel to the cleavage traces. None of the hornblende present shows euhedral or even subhedral outlines.

Biotite is far less plentiful than hornblende, but is regularly distributed throughout the sections in fair quantity. The pleochroism of the mineral is normal and strong. The biotite has apparently been very resistant to alteration in any form; only in very rare cases may a slight change to *chlorite* be observed.

The opaque minerals are apparently of three different kinds. *Ilmenite,* shown by its change to leucoxene, is plentiful, and is scattered in irregular grains throughout the rock. *Pyrites,* generally in larger grains, is, however, not as plentiful as ilmenite. It occasionally shows its cubic form. *Magnetite* occurs as minute inclusions in the hornblende.

Apatite, as an accessory mineral, is plentiful. It is present, sometimes in small irregular grains, but generally in its characteristic rod-like form.

The presence of a small amount of *sphene* is interesting in a rock of this degree of basicity, as all the other rocks described from this area contain this mineral. The sphene present in this rock is pleochroic, and is of a light-brown colour. It occurs in irregular anhedrons.

The order of crystallisation seems to have been:—(1) iron ore, (2) basic labradorite, (3) acid labradorite, (4) biotite, (5) hornblende.

B. F. Goode has made a chemical analysis of this rock, the results of which are given below:—

CHEMICAL COMPOSITION OF THE BASIC ROCK.

	Per cent.		Per cent.
Silica (SiO_2)	46·79	Soda (Na_2O)	3·38
Alumina (Al_2O_3)	18·09	Potash (K_2O)	0·77
Ferric oxide (Fe_2O_3) ..	4·07	Water (H_2O)	0·40
Ferrous oxide (FeO) ..	7·05	Titanium dioxide (TiO_2) ..	1·99
Magnesia (MgO)	7·31	Phosphorus pentoxide (P_2O_5)	0·46
Calcium oxide (CaO) ..	9·67		
		Total	99·98

The specific gravity is 3·03.

THE NORM.

	Percentage.		
Orthoclase	4·45		Salic Group = 64·24%
Albite	27·25	F = 63·39	
Anorthite	31·69		
Nepheline	0·85	L = 0·85	
Diopside	10·69	P = 10·69	Femic Group = 35·45%
Olivine	13·92	O = 13·92	
Ilmenite	3·80		
Magnetite	6·03	M = 9·83	
Apatite	1·01	A = 1·01	
Water	0·40		

In the C.I.P.W. classification the position of the rock is, therefore:—
II., 5, 4, 4-5.

The magmatic name is *Hessose*.

Discussion of the Analysis.

No points of special interest are disclosed by these figures, the results of analysis appearing normal in every way. Perhaps the most notable point is the high percentage of titanium.

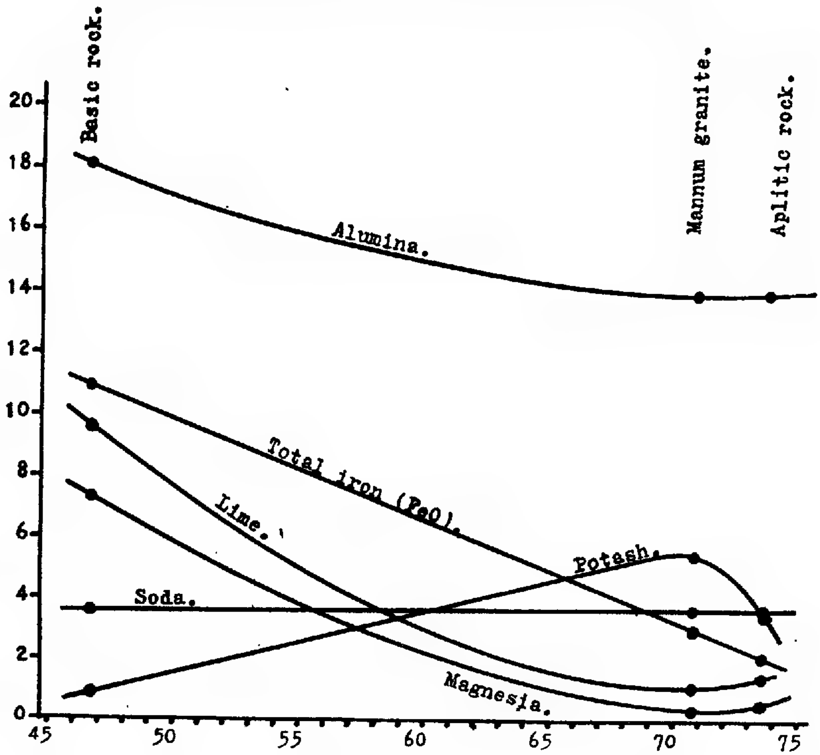
The low silica percentage (46·79) places the rock in the basic class, and the absolute dominance of basic plagioclase (*i.e.*, labradorite) makes it a member of the calc-alkali series. These facts, together with the mode of occurrence and the mineralogical character of the rock, class it as a *hornblende-lamprophyre*. The name hornblende-lamprophyre is preferred to that of Spessartite, which was suggested by Rosenbusch for a lamprophyre of this description.

Comparison of the Analyses of the Mannum Rocks.

The interpretation of the results obtained by the chemical analysis of such rocks is necessarily a difficult matter. It is obvious that some method of graphically representing chemical analyses will often show points of interest which would not be realized directly from the analyses themselves. The method of comparison used in this paper will be that known as the "variation-diagram." The percentages of silica are taken as abscissae, and the percentages of the other main constituents are plotted as ordinates. For purposes of representation, all the iron is reckoned as ferrous. The constituents, besides silica, shown on the diagram are:—alumina, total iron, magnesia, lime, soda, and potash.

It will be seen that the analysis of each rock is represented by a number of points on a vertical line.

VARIATION DIAGRAM FOR MANNUM ROCKS.



Percentage of Silica.

The above variation diagram does not tend to show any simple form of relationship between the three rocks represented in it. With two exceptions, no simple gradation is shown in the proportion of the constituents from the basic end to the acidic end of the series. These two exceptions are iron and soda, the variation-curve in each case being a straight line. It will be seen from the diagram that the curves for alumina, magnesia, and lime are all concave upwards, the last-mentioned notably so. However, the point of greatest note is the behaviour of the potash line. The sharp bend downwards at the acidic end denotes an unusual variation.

From these facts it would appear that if the basic rock and the acidic rock, here described, were derived by magmatic differentiation from the normal Mannum granite, then this differentiation must have been of an exceedingly complicated and abnormal kind.

The point which now arises is this. Are we justified in taking the composition of the Mannum granite, as is revealed to us by chemical analysis, as being representative of the original composition of the parent magma? Several points tend to show that the answer to this question should be in the negative.

These points are:—

(1) *The general appearance of the rock.* It does not possess that "plutonic facies" which is generally associated with a normal bathylithic granite. The great preponderance of felspar in the rock helps to give it the appearance which it possesses.

(2) *The small extent of the occurrence.* This fact suggests that the granite represents some small "cupola" at the roof of a huge granitic bathylith. It is reasonable to expect that the lighter, more felspathic portions of the magma would be found at the top of the intrusion, that is particularly in the cupolas. This point is supported by—

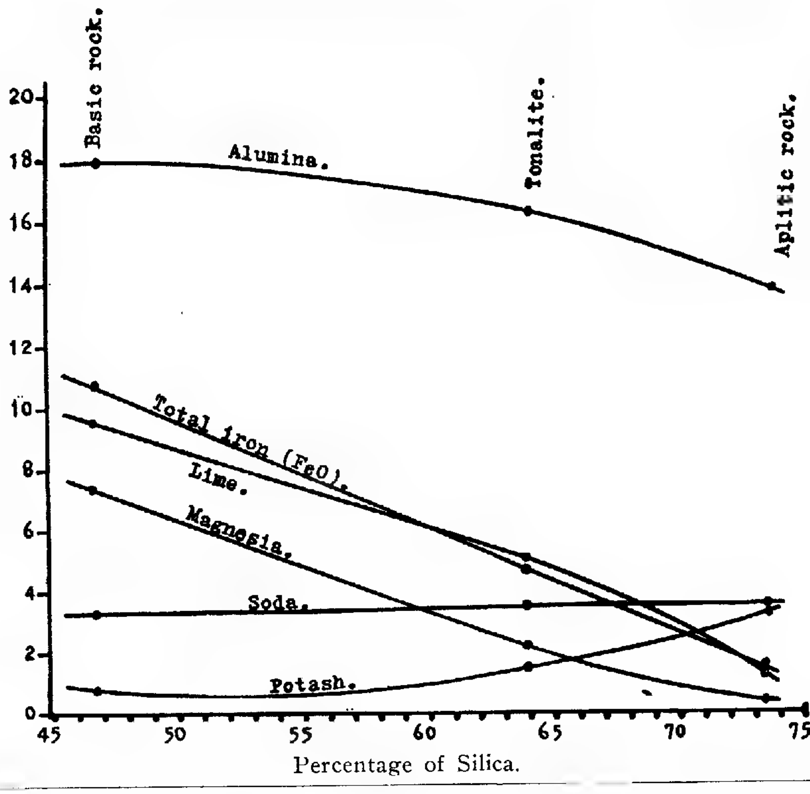
(3) *The chemical composition of the rock.* As can be seen by reference to the chemical analyses quoted earlier in this paper, the Mannum granite differs from the other South Australian granites which occur within a reasonable distance of it. Particularly is it different in its potash content. As has been suggested above, this may be accounted for by the concentration of felspar at the roof of a bathylithic intrusion.

These points naturally introduce another question. If, then, we do not regard the granitic rock at Mannum as being truly representative of the parent magma, what rock can we find which fulfils these requirements?

In a case such as this the distance factor is an exceedingly important one. Therefore, the rock which may very well be considered first is the tonalite, which occurs roughly halfway between the townships of Mannum and Palmer and has been described by the writer.(3) It is very probable that this tonalite extends below the surface covering of Tertiary sediments and Recent alluvial for a considerable distance in the direction of the Mannum granite quarries.

In order to compare the chemical compositions of the Mannum dyke rocks with the tonalite, use has been made of the same type of variation diagram as was previously employed.

VARIATION DIAGRAM FOR TONALITE AND MANNUM DYKE ROCKS.



(3) Trans. Roy. Soc. S. Austr., vol. li., 1927, pp. 20-22.

A glance at the above diagram is sufficient to show the great difference between this and the previous one. The relationship of each constituent is of the simplest kind, there being definite gradation from one rock to another, as is shown by the straight lines, or almost straight lines of each variation-curve.

From the *linear* variation of the constituents of these rocks, it would appear highly improbable that the rocks were not very closely related, and that the differentiation was not of a very simple type. Dr. A. Holmes,[4] discussing linear variation-diagrams, says "the fact that even with three analyses a straight line diagram is achieved, indicates that the rocks concerned are related in an unusually simple way."

The fact that these rocks are very closely related to one another does not, however, show that the tonalite is the parent rock from which the Mannum dykes have been differentiated. Although the possibility of this must, of course, be considered, it must be admitted that the probability of it is not very great.

Previously, in this paper, attention has been drawn to the fact that the aplitic rock at Mannum bears a great resemblance chemically to the granites occurring at Palmer, at Monarto, and at Swanport. In the case of all these rocks, for instance, the soda and potash in each are very nearly the same. It thus appears to the writer that the dyke rocks at Mannum and the tonalite were derived from a granitic magma, which was not very different in composition to the granites of Palmer, Monarto and Swanport. The average of the compositions of these three granites for the main constituents is:—

	Per cent.		Per cent.
SiO_2	73·53	MgO	0·32
Al_2O_3	14·50	CaO	1·34
Fe_2O_3	0·93	Na_2O	3·46
FeO	0·99	K_2O	3·56

The similarity of these averages to the composition of the acidic dyke rock from Mannum is very striking. It seems possible to the writer that the granites of Palmer, Monarto and Swanport are all derived from one parent magma, the slight lithological and chemical differences being but local variations, and that the tonalite and the dyke rocks of the Mannum district are very simply related to the same magma. The Mannum granite was very probably derived from the same source by a more complicated method of differentiation.

Summary.

Chemical analysis of the basic and aplitic dyke rocks at Mannum, shows no simple relationship between these rocks and the granite in which they occur. These dyke rocks, however, seem to be very simply related to a tonalite which occurs in the neighbourhood. The Mannum granite was very probably derived from the same magma as the tonalite and the dyke rocks, by a more complex method of differentiation.

Acknowledgments.

The thanks of the writer are due to Professor Sir Douglas Mawson for his help and advice, and also for placing the facilities of the geological laboratories of the University of Adelaide at the writer's disposal. He also wishes to thank Mr. B. F. Goode for permission to use the analysis of the Mannum lamprophyre.

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University of Adelaide.

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(4) "Petrographic Methods," 1921, p. 446.

THE CRYSTAL FORMS OF PYROMORPHITE AND STOLZITE.

By J. O. G. Glastonbury, B.Sc., and F. J. Semmens, B.Sc.
(Communicated by C. T. Madigan, M.A., B.Sc., F.G.S.)

[Read September 12, 1929.]

The purpose of this contribution is to place on record the forms assumed by certain well-crystallised minerals occurring at Broken Hill.

The nomenclature of the faces is that employed by Barker in his "Graphical and Tabular Methods in Crystallography."

The angular measurements were obtained by means of Goldschmidt's two-circle goniometer, which admits of determinations accurate to 30″. The system of recording the position of faces is that of two-circle work, not the zone method of single-circle goniometry. The ϕ readings are on the vertical circle, and the p readings on the horizontal.

Pyromorphite from Broken Hill, N.S.W.

Well-developed crystals of pyromorphite were obtained from Broken Hill, N.S.W. Their colour is yellow, with resinous lustre. The crystals are small and often bunched together, so that usually they are singly terminated. Some occur in vughs, where they attain perfect form. It was with these crystals that we worked mainly. From measurements of crystals which, owing to their contact with others, had the faces at one end suppressed, we found that the forms developed were essentially the same as those crystals which, owing to more favourable circumstances, were fully developed.

Pyromorphite is in the pyramidal hemihedral class of the hexagonal system.

The c-axis, calculated from the measurement of the angle $0001 \wedge 10\bar{1}1$ ($=40° 22'$) of several crystals from Broken Hill, is 0·7362, which agrees with Haidinger's determination as recorded in Dana (1).

There are two common types of crystal. One is very simple, consisting of

a hexagonal prism m,
a hexagonal bi-pyramid p,
and basal planes c (see fig. 1).

The other type is similar to the first, but it has a second order hexagonal prism, s developed as well (fig. 2).

We observed that the dull brown variety of pyromorphite, which looks like clusters of small cauliflowers, does not exhibit this second order prism. This is true of this coloured variety found at Broken Hill, and also of similar material from Ems, Nassau. O. Bowles (2) observed this form ($11\bar{2}0$) on wax yellow crystals from the Society Girl Mine in South-Eastern British Columbia, but he, too, did not observe it in any of the brown crystals with which he worked. It thus seems that this face is found only on the yellow variety of pyromorphite.

The crystals are prismatic in habit, elongated parallel to the c-axis. The prismatic faces often do not exhibit perfect parallelism but converge towards the end of the c-axis, thus giving the crystals a barrel shape. Bowles points out that this non-parallelism is due to vicinal faces, but he does not mention the fact that curvature takes place towards both ends of the c-axis, thus producing the barrel shape of the crystals.

No twinned crystals were seen, although they are recorded by Klein (3) and Bowles.

The angular measurements obtained, and the forms present, are shown in the table:—

Forms	m	s	c	p
	$(10\bar{1}0)$	$(11\bar{2}0)$	(0001)	$(10\bar{1}1)$
ϕ	90°	60°	—	90°
ρ	90°	90°	0°	40° 22′

Stolzite from Broken Hill, N.S.W.

Some small crystals of stolzite from the Proprietary Mine, Broken Hill, N.S.W., are to be seen in the Tate Museum, University of Adelaide. These crystals are of an orange colour, and occur on the surface of black manganiferous material in the zone of solution. They are extremely well crystallised, and faces are quite often developed at both ends of the crystal.

Stolzite is in the Tetragonal system, and shows pyramidal hemihedrism.

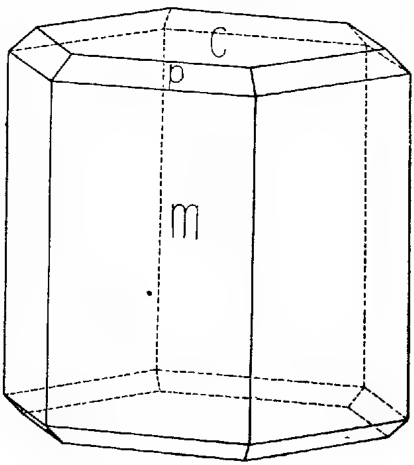

Fig 1

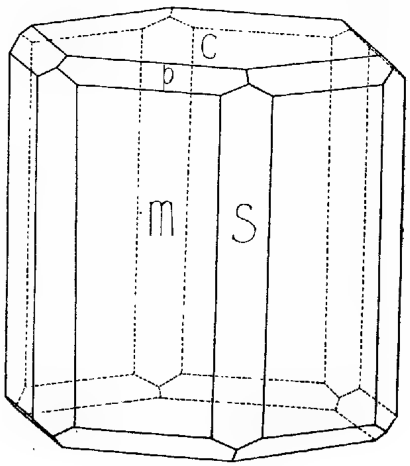

Fig 2

The c-axis, calculated from the angle $001 \wedge 101$ (= 57° 27′) is 1·5667, agreeing with Kerndt (Dana), but not with C. Hlawatsch, who is quoted as giving 1·5607 in Dana (4).

Three combinations of crystal forms were noticed; two of these being very common, and the third much rarer.

Of the two common types, both of which were simpler than the third, one was very simple indeed, consisting of

a tetragonal by-pyramid of the first order, o,
a tetragonal by-pyramid of the second order, q,
and basal planes, c (fig. 3).

The other was more complex, having, in addition,

two-third order by-pyramids, x, and y (fig. 4).

This type showed that stolzite belongs to the Pyramidal Hemihedral class of the Tetragonal system, and not to the full symmetry class, as the first type would lead one to think.

The third type was much rarer; in fact, of some twenty specimens measured, only two showed these forms.

This type has, in addition to the forms mentioned above, three other second order by-pyramids, *d*, *e*, and *s*; and also a first order tetragonal prism, *m*, and a second order tetragonal prism, *b*.

The third order tetragonal by-pyramid, *y* (212), has not previously been recorded.

The angular measurements obtained, and the forms developed, are:—

Forms	*c*	*d*	*e*	*q*	*s*	*x*	*o*	*m*	*y*	*b*
	(001)	(013)	(023)	(011)	(021)	(133)	(111)	(110)	(212)	(010)
ϕ		0°	0°	0°	0°	18° 28′	45°	45°	63° 26′	0°
p	0°	27° 37′	46° 15′	57° 27′	72° 18′	59° 19′	65° 43′	90°	60° 9′	90°

In several crystals the first order tetragonal bi-pyramid, *o*, was striated parallel to the edge (111)—(110). In these cases the reflections obtained were not well defined.

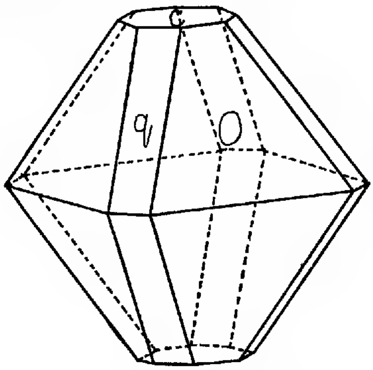

Fig. 3

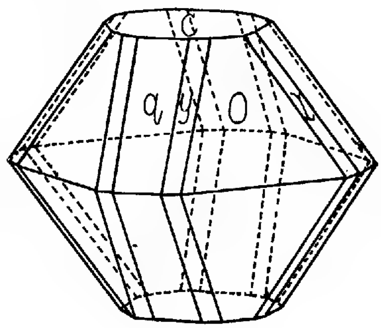

Fig 4

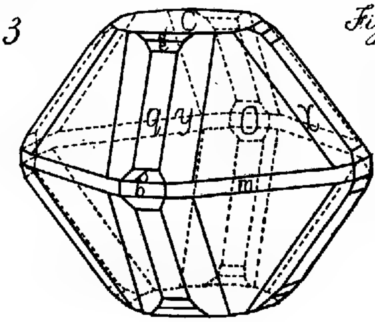

Fig 5

Some crystals exhibited twinning, but we were unable to determine the type.

We are deeply indebted to Mr. C. T. Madigan for much advice and encouragement in this work.

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University of Adelaide.

List of References.

1. Haidinger—Dana, "System of Mineralogy," p. 770.
2. O. Bowles—Am. J. Sc., v. xxviii., p. 40, 1909; v. xxxii., p. 114, 1911.
3. Klein—Dana, "System of Mineralogy, App. I."
4. C. A. Hlawatsch—Dana, "System of Mineralogy, App. II."

ADDITIONS TO THE FLORA OF SOUTH AUSTRALIA.
No. 27.

By J. M. Black.

[Read September 12, 1929.]

Gramineae.

Danthonia geniculata, nov. sp. Culmi tenues, 10-35 cm. alti, prope basin saepe geniculati; folia filiformia pubescentia, radicalia dense caespitosa, 4-6 cm. longa, caulina brevia distantia; panicula densa $1\frac{1}{2}$-$2\frac{1}{2}$ cm. longa, 1-$1\frac{1}{2}$ cm. lata, 5-15-spiculata; spiculae 4-5-flores, glumis exterioribus latis, 6-8 mm. longis, e viridi pallentibus; gluma florifera usque ad ortum aristae 2-$2\frac{1}{2}$ mm. longa, ad basin et supra medium annulo pilorum cincta vel pilis superioribus subsparsis, lobis lateralibus 4-$5\frac{1}{2}$ mm. longis lanceolatis et brevissime aristatis, aristâ centrali iis vix longiore; palea obovata obtusa dorso pubescens, $2\frac{1}{2}$mm. longa.

Keith; Bordertown; Dismal Swamp (near Mount Gambier); Millicent; Kangaroo Island.—Victoria (Hawkesdale). Resembles in habit *D. carphoides* with smaller spikelets, but the 2 lateral lobes of the flowering glume are twice as long as the basal part, lanceolate instead of ovate and taper into distinct awns; the palea is also much smaller.

Danthonia auriculata, nov. sp. Culmi tenues, 20-30 cm. alti, interdum geniculati; folia pilis patentibus pubescentia, filiformia vel caulina planiuscula et circiter 2 mm. lata; panicula densa interdum ad racemum reducta, $1\frac{1}{2}$-3 cm. longa, $1\frac{1}{2}$-2 cm. lata, 4-15-spiculata; spiculae 5-8-flores, aristis glumas exteriores latas cymbiformes pallide virides 10-13 mm. longas superantibus, pedicellis 2-3 mm. longis; gluma florifera usque ad ortum aristae 3 mm. longa, ad basin et supra medium annulo conspicuo pilorum cincta, lobis lateralibus 7-10 mm. longis, in aristam gracilem pro plus quam dimidio longitudinis eorum angustatis, utroque lobo auriculâ triangulari membranaceâ ad basin marginis exterioris instructâ, aristâ centrali quam lobi laterales 2-3 mm. longiore; palea ovato-cuneata obtusa, 4 mm. longa, dorso pubescens.

Adelaide plains and foothills; Jamestown, Bundaleer Hills. This species also resembles *D. carphoides* externally, but is distinguished both from that species and from *D. geniculata* by the longer and long-awned lateral lobes, the longer central awn, and especially by the small triangular membraneous auricle at the base of each of the 2 lateral lobes, where they are joined to the basal part of the flowering glume.

Cyperaceae.

Cladium monocarpum, nov. comb. = *Schoenus monocarpus,* J. M. Black in Trans. Roy. Soc. S.A. 52:225 (1928).

Back Valley, near Inman River; Breakneck River, K.I., coll. J. B. Cleland. This plant appears to be better placed in *Cladium* than in *Schoenus,* the rhachilla of the spikelets being straight and not flexuose between the flowers. Like *C. capillaceum* (Benth.) C. B. Clarke it has the glumes subdistichous and close together, but the stems are not so slender, the spikelets are longer and the nut is not crowned by the thickened base of the style.

Cladium gracile, nov. sp. Caules plani debiles striati, 12-20 cm. alti, minus quam 1 mm. lati; folia basalia, equitantes, saepe longiora quam caulis, plana, linearia, acuta, striata, circiter 1 mm. lata; spiculae circiter 3-6, distantes, pedicellatae, racemum laxum vel paniculam formantes; bracteae vaginantes, inferiores

planiusculae, laminis brevibus debilibus erectis, superiores glumiformes; spiculae 4-5 mm. longae, 1-flores; glumae subdistichae, brunneae, acutae, una alterave vacua, proxima superior florem triandrum trigynum atque glumam vacuam parvam complicatam includens; nux obovoidea, trigona, cum apice rotundato pubescente.

Breakneck River, Kangaroo Island. Differs from *C. acutum* (Labill.) Poir. in the weak, not rigid leaves and much looser panicle; from the West Australian *C. laxum* (Nees) Benth. by the smaller stature, narrower leaves and fewer spikelets, with only 1 flower instead of 2-3.

Leguminosae.

Acacia microcarpa, F. v. M. nov. var. *linearis*. Phyllodia late linearia, 3-6 cm. longa, 2½-3 mm. lata, mucronata; legumen supra semina 5 mm. latum.—Near Monarto South.

Acacia peuce, F. v. M. Specimens of this rare species were collected by Dr. Ward on Andado Station, C. Aust., about 60 miles north of our border. More recently Professor Cleland and Mr. Madigan received samples of the phyllodia at Birdsville, Qld., to which place they had been brought by Mr. L. Reese, owner of Minnie Downs Station, which is in South Australia, close to the Queensland border. They were collected about 15 miles north of the boundary of our State. At Andado Station this Acacia forms a small and strictly localized grove of trees up to 12 m. high and called the "Sheoaks" on account of the resemblance due to the drooping branchlets and slender phyllodes. The type came from north of Wills Creek, Qld., and Mueller described the phyllodia as "2-4 inches long." Some of them are, however, fully 25 cm. (nearly 10 inches) long, very slender, rigid but fragile, conspicuously tetragonous and pale in colour. The pod is flat, up to 15 cm. long and 4 cm. broad. The seeds are transverse, distant, compressed, ovate, about 10 mm. long. Withered flowers show that the sepals are usually 5, scarcely 1 mm. long, linear-lanceolate, ciliate, shortly united near base, the petals 2½ mm. long, acuminate, glabrous, united near base. The shape and size of the flowerhead is not yet known. The type, collected during Howitt's expedition and delivered to Baron von Mueller, had evidently only short phyllodes, but the tree is accurately described—"Pini vel Casuarinae imaginem exhibens." Specimens of the wood, turned and polished in Adelaide, display varied and beautiful colours. Near Birdsville, according to Mr. Reese, the tree is named "Waddy."

Rutaceae.

Correa calycina, nov. sp. Frutex ramulis laxe tomentosis; folia oblonga vel ovato-oblonga obtusa crassiuscula, 2-4 cm. longa, supra glabrescentia viridia, subtus pallidiora stellato-pubescentia; pedunculi brevissimi; calyx subcampanulatus, circa 12 mm. longus, extus sparse stellato-pilosus, intus stellato-tomentosus, lobis latis, breviter acuminatis, tubum subaequantibus; petala cohaerentia, 20-25 mm. longa, rubescentia vel subviridia; stamina exserta, 4 filamentis alternis valde dilatatis; ovarium sericeum.

Upper Waterfall, Hindmarsh Valley. Differs from *C. reflexa* in the narrower, greener leaves, larger calyx with much longer lobes; has somewhat the aspect of *C. aemula*, but the leaves are obtuse and mostly narrower and the calyx-lobes broader and never conspicuously longer than the tube, while the petals cohere, and the peduncles are very short and without bracts. *C. calycina* has, so far, been found only in the one locality; collector, J. B. Cleland.

Compositae.

Helichrysum ambiguum, Turcz. nov. var. *paucisetum*. Variat, ut typus, magnitudine et indumento foliorum; pappi setae 4-8 in floribus bisexualibus,

aliquae aut omnes basi dilatatae et denticulatae, supra basin defractae; flores feminei sine pappo in omnibus capitulis inspectis.

South Australia (Cordillo Downs and Hamilton Bore, coll. J. B. Cleland; Ooldea, coll. Mrs. Daisy Bates;) Central Australia (Idracowra, coll. R. Tate; Depot Sandhills, River Finke, coll. S. A. White;) Western Australia (Barrow Range, coll. R. Helms).

Helichrysum Basedowii. The collation of further specimens shows that this species, described by me in these Transactions 52: 230 (1928) cannot be separated from *Leptorrhynchus tetrachaetus* var. *penicillatus,* J. M. Black in Trans. Roy. Soc. S.A. 45: 19 (1921). It appears to me to be worthy of specific rank and to be better placed in *Helichrysum.* Its distribution extends from the Flinders Range to our northern boundary in the Musgrave Ranges, and it will probably be found in Central Australia.

Basedowia helichrysoides, E. Pritzel in Fedde, Rep. 15: 360 (1918). An inspection of the type of *Humea tenerrima,* F. v. M. et Tate in Proc. Roy. Soc. S.A. 16: 368 (1896), lent by the Victorian National Herbarium, proves that these names are conspecific, and I have already altered the name in the Flora of South Australia to "*Basedowia tenerrima* (F. v. M.) nov. comb." Neither specimen shows the base of this delicate little plant, which appears to be very rare. Mueller's specimen was collected by R. Helms near Mount Ilbillee (Everard Range); Pritzel's by Dr. Basedow "in central part of South Australia."

Athrixia tenella, Benth. nov. var. *horripes.* Pedunculi squamis plumosis superne instructi, quae squamae bracteas exteriores involucri simulant.—Karoonda (Murray lands). This form approaches the West Australian *A. Croniniana,* F. v. M., but the pappus-bristles are those of *A. tenella.*

Myriocephalus rhizocephalus, (DC.) Benth. nov. var. *pluriflora.* Capitula partialia 4-5-flora, bracteis 5-7 lanatissimis.—Flinders Range (between Lakes Torrens and Frome).

Sonchus megalocarpus (Hook. f.), nov. comb. Herba perennis robusta erecta stolonifera, 20-60 cm. alta; folia crassa coriacea, caulina oblonga in lobos rotundatos aculeato-dentatos pinnatifida vel indivisa et sinuato-dentata, omnia auriculis latis rotundatis amplexicaulia; capitula in corymbos inaequales disposita; involucrum 18-20 mm. longum glabrum vel in bracteis exterioribus subsetosum; achaenia ovato-oblonga straminea vel brunnea, 6-7 mm. longa, 2-3 mm. lata alis adnumeratis, absque 3 costis longitudinalibus laevia.—*S. asper,* Hill var. *megalocarpus,* Hook, f. Fl. Tasm. 1: 227 (1860); var. *littoralis,* J. M. Black, Nat. Fl. S.A. 104 (1909), et probabiliter var. *littoralis,* Kirk in Trans. N.Z. Inst. 26: 265 (1894).

Chiefly sandhills along the coast from Port Adelaide to Port MacDonnell, S.-E. —Coasts of Victoria, New South Wales, Tasmania, and, probably, New Zealand.

AN INTERESTING NEW THRIPS FROM AUSTRALIA.

By Dudley Moulton.

(Communicated by Arthur M. Lea, F.E.S.)

[Read September 12, 1929.]

Plate XI.

Among a large collection of Thrips sent to me from the South Australian Museum, I found one very unusual form which is unlike anything previously known. The greatly enlarged fore legs give it the general appearance of a crab, and it would seem from the form of these legs that the species must be predaceous. The genus and species are described herewith.

Carcinothrips, n. gen.

(Karkinos = crab.)

Head approximately twice as long as wide. Eyes large and protruding, occupying two-thirds the width of the head. Cheeks straight, constricted at base, armed with eight to ten strong spines on either side, not on warts. Antennae 8-segmented.

Prothorax large and excluding coxae, broadly hexagonal in shape. Fore femora greatly enlarged, about 1·75 times as long and 1·5 times as wide as head. The armature at the end on the inside of each consisting of three strong forward directed teeth. The tibiae are reduced to small horn-shaped appendages directed inward, and each ends in two horn-shaped teeth. The two outer teeth of the femora appear to fit between the two distal teeth of the tibiae. The tarsi are extremely rudimentary and appear to be useless organs in the middle on the underside of the tibiae. Pterothorax broad in front with nearly straight sides, narrowed posteriorly. Femora of middle and hind legs greatly broadened in the centre, strongly ovate in shape, each arising from an extremely small pedicel. Middle and hind tibiae and tarsi short and stout. Wings fully developed, broad, with parallel sides. Abdomen normal, tube slightly more than half as long as head.

Type of genus *Carcinothrips leai*, n. sp.

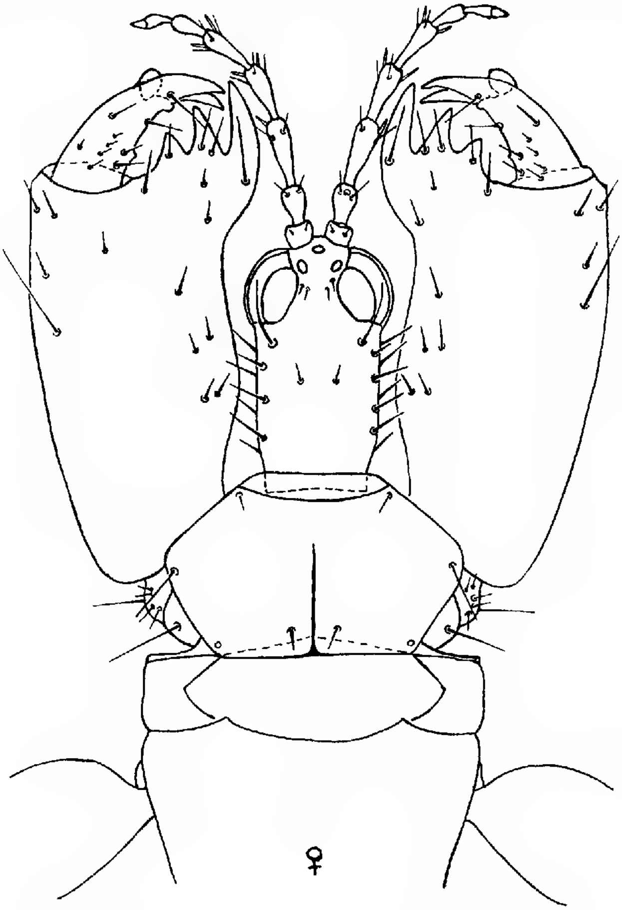
Carcinothrips leai, n. sp.

Female holotype: Colour of head, prothorax and fore legs brownish yellow, with teeth of fore femora decidedly darker. Antennal segments one and two brown, the second being lighter toward the tip, three to seven yellow, brown at extreme tips, eight brown. Pterothorax and abdomen dark brown, middle and hind legs concolorous with abdomen except inner sides of femora, which are shaded lighter. Wings clear.

Total body length 2·74 mm.; head, length ·483 mm., width at eyes ·26 mm., at middle ·23 mm.; prothorax length ·30 mm., width in middle not including coxae ·516 mm., including coxae ·6 mm.; pterothorax, width ·6 mm., width at posterior margin ·43 mm.; width of abdomen ·55 mm.; tube, length ·266 mm., width at base ·10 mm. Length of fore femora along outer margin to base of tibia ·75 mm., from base to tip of inner tooth on the inside ·916 mm., width in middle ·383 mm. Length of middle femora ·433 mm.; width in middle ·233 mm.; length of hind femora ·50 mm.; width in middle ·266 mm. Length of spines: postoculars

135 mic., cheek spines 90 to 100 mic., at anterior angles of prothorax 45 mic., mid-laterals 60 mic., outer pair on posterior angles 35 mic. (inner pair broken off). Spines on ninth abdominal segment 210 mic., at tip of tube 285 mic. Segments of antennae: length (width) I., 39 (48); II., 75 (45); III., 126 (39); IV., 111 (42); V., 96 (39); VI., 75 (36); VII. 60 (?); VIII., 30 (?); total length, 585 microns.

Head slightly more than twice as long as width across cheeks, not noticeably projecting in front of eyes. Cheeks almost straight and parallel to near base, where they are constricted neck-like, without conspicuous markings, with eight



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to ten strong, sharp spines along either side. Postocular spines long and with pointed tips. Eyes large, semi-oval, clearly protruding, facets small. Ocelli fully developed, placed far forward. Mouth cone short, extending only to middle of prosternum, broadly rounded. Antennae 8-segmented, about 1·2 times longer than head, segments three to six elongate-clavate, seven to eight closely joined but distinct; sense cones short.

Prothorax broadly hexagonal in shape, with a median dorsal thickening arising at one-fourth its length from anterior margin, and extending to the posterior margin. Spines at anterior angles and sides moderately small, those long anterior margin vestiginal, outer spines of posterior angles long, inner spines broken off. All spines with pointed tips. Pronotum without other markings. Pterothorax

broadest in anterior half, conspicuously narrowed posteriorly. Fore legs greatly enlarged and strongly armed. Each fore femur about 1·75 times as long and 1·5 times as wide as head, armed on the inside with three strong, forwardly directed teeth, the innermost of which is longest. The tibiae greatly reduced, projecting inwardly in front of the armed femora, these are horn-shaped and end in a pair of teeth which appear to fit on either side of the two longer teeth of the femora. Each tibia also with two blunt knobs on the inside which fit on either side of the shorter, outer femoral tooth. Tarsi apparently useless, appearing as rudimentary appendages on the underside near the middle of the horn-shaped tibiae. Wings fully developed, short and broad, appearing to be without double fringe hairs.

Abdomen normally developed with segments two to seven of almost equal width. Tube 2·5 times longer than width at base and little more than 1·5 as long as head.

Type Material: Female holotype collected by Mr. A. M. Lea and named in his honour. On *Acacia* sp. in September. Type deposited with South Australian Museum, Adelaide. (Moulton, No. 3,116).

Type locality: Barton, South Australia.

EXPLANATION OF PLATE XI.

Carcinothrips leai Moulton. Greatly magnified.

THE SPREADING TENDENCY OF SOLUTIONS OF VARIOUS ACIDS AND SALTS UPON A CLEAN MERCURY SURFACE.

By R. G. MITTON, M.Sc.
(Communicated by R. S. Burdon, B.Sc., F.Inst.P.)

[Read September 12, 1929.]

I. INTRODUCTION.

1. *The Spreading of Solutions on a Mercury Surface.*

Attention was drawn in 1925, in a paper by Burdon,[1] to a number of phenomena which accompany the spreading of drops of distilled water and drops of aqueous solutions of various acids or salts upon a freshly-prepared mercury surface.

It was found that if mercury, perfectly free from any traces of greasy contamination, was poured in a carefully cleaned glass dish in the presence of air, then:—

(1) a drop of a solution of an alkali in distilled water showed no tendency to spread on the mercury surface;

(2) a drop of distilled water or very pure conductivity water spread slowly and uniformly to a thin circular disc;

(3) a drop of a solution of an acid or salt in distilled water spread in a flash across the mercury surface.

By using increasingly dilute solutions a curious phenomenon became apparent. For a given dilution a drop of acid or salt solution flashes out over the mercury surface to a perfectly definite area maintaining a circular shape, and then continues to spread slowly and uniformly at about the same rate as distilled water. The dilution at which this effect became apparent was found to be much greater for acids than for salts.

It was found further that, using acids of varying strength between ·00008 normal and ·0004 normal, the area of surface covered during the brief instant of rapid spread was directly proportional both to the size of the drop and to the concentration. Moreover, the area covered was found to be practically independent of the particular acid employed, being almost the same for a weak acid such as butyric as for hydrochloric or nitric acid. Dibasic acids, it was found, spread to twice the area per molecule covered by monobasic acids. The actual area covered was about one sq. cm. for each 10^{14} molecules of the acid present. It was argued, therefore, that it was improbable that a monomolecular film was formed on the mercury surface, since even under the assumption that all the molecules of acid come into contact with the mercury surface during the short time that rapid spread is taking place, there can still be only one molecule of acid present for every ten atoms in the mercury surface.

2. *Measurements with Adsorbed Films upon a Water Surface.*

Introductory experiments of a qualitative nature by Rayleigh[2] and by Miss Pockels[3] led finally to the more accurate measurements of Langmuir,[4]

(1) Proc. Phys. Soc. Lond. 38, 2, p. 148.
(2) Proc. Roy. Soc., vol. xlvii., pp. 281, 364; vol. xlviii., p. 127.
(3) Nature, vol. xliii., p. 437.
(4) Jour. Am. Chem. Soc., xxxix., 2, 1917, p. 1,848.

Adam,[5] and Adam and Jessop[6] of the pressure exerted by a thin film of fatty acid molecules adsorbed upon a water surface.

By consideration of the amount of fatty acid placed upon the water surface and of the "pressure"[7] exerted by the film against a floating barrier, these experimenters have been able to show that in general the films are only one molecule thick, and that the molecules of the adsorbed substance are all oriented with the long chains projecting vertically out of the water surface. The molecules are attached to the water by the more active portion of the molecule which is, so to speak, immersed in the water while the remainder of the molecule, having no affinity for the water, projects vertically out of it. The fact that molecules of the same series were found to occupy the same area of the water-surface per molecule, independently of the length of the chain, led to measurements of the areas of cross section of the molecules. For most of the substances examined this area was found to be about 21×10^{-16} sq. cm.

Further work by Adam and Jessop *(loc. cit.)* led to the consideration of the films as existing in three phases corresponding to the gaseous, liquid, and solid phases in three dimensions, and a very close analogy has been drawn between the behaviour of an ordinary gas and the behaviour, at very low pressures, of the adsorbed films. Under these low pressures the films may be regarded as equivalent to gases in two dimensions, each molecule in them being able to move freely in any direction upon the water surface but being confined to this plane. In particular, two laws have been adduced experimentally which are exactly analogous to Boyle's Law and the perfect gas law for ordinary gases.

Thus, if the "two dimensional pressure" *(i.e.,* the force per unit length exerted against the barrier) is F, the area of the water surface for each molecule of the adsorbed substance is A, k is a constant, R the constant of the gas equation $pv = R\theta$, and θ is the absolute temperature, then it is found that:—

$FA = k$ at a constant temperature,

and $FA = R\theta$ when the temperature is allowed to vary.

So interesting and important were the results obtained by this group of experimenters in their measurements of the pressures exerted by films on a water surface, that it seemed worth while to attempt a quantitative measurement of the pressures exerted when various acids and salts had spread on a mercury surface, and the present paper represents the outcome of these experiments.

II. Apparatus Employed and the Preparation of Materials.

About the same time as the experiments of Adam and Jessop, Marcelin[8] had attempted the measurement of the pressure exerted by films upon a water surface by means of two different types of apparatus.

The first of these was operated upon the principle of the aneroid barometer and may be understood in reference to the plan given in fig. 1.

Fig. 1.

[5] Proc. Roy. Soc. A. 99, p. 336. A. 101, p. 452, etc.

[6] Nature, April, 1926, p. 484.

[7] The term "pressure" will be often used in the present paper in the sense in which Adam uses it, of force per unit length of the barrier.

[8] Marcelin, Ann. de Phys. 10th Ser., 4, 125, p. 459.

Three sides of a rectangle, open above and below, consisted of a rigid framework AB, BC, CD, while the fourth side was constructed of a thin flexible sheet of mica AD. The whole was allowed to float on a water surface and, a drop of fatty acid dissolved in benzine having been placed within ABCD, the movement of the central portion of the mica, magnified by a suitable lever system, served to measure the pressure of the film. This method was found to be only sufficiently sensitive to register comparatively large pressures of the surface films.

The second type of apparatus depended upon the principle of the torsion balance, and was used by Marcelin and Delaplace in the measurement of low pressures as well as those of the more compact film.

A shallow trough abcd containing water was placed inside a glass case ABCD (fig. 2) in order to protect the surface, so far as possible, from dust contamina-

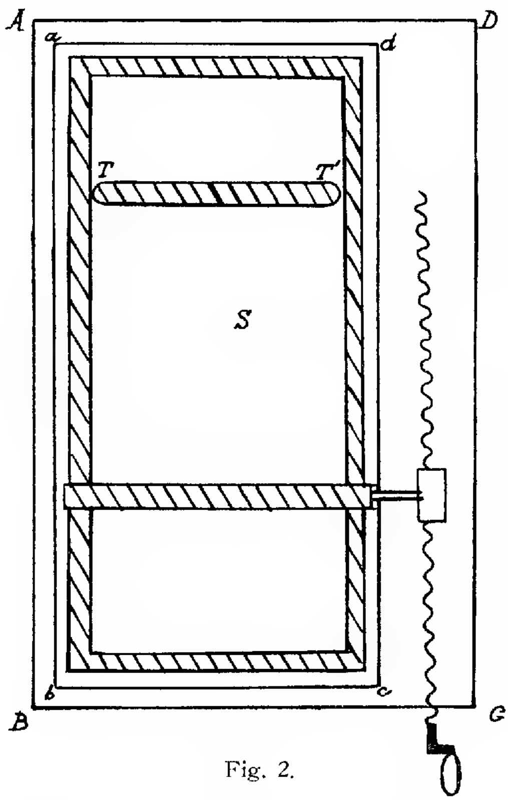

Fig. 2.

tion from the air. Floating upon the water was a hollow rectangle of celluloid (shown shaded in the figure), which was held in position by four needles passing vertically through holes at the corners of the celluloid rectangle. A barrier TT′ floated upon the water and was attached to a torsion wire and a torsion head directly above T′. Thus the barrier could turn about T′ in opposition to the torsion in the wire. In taking a measurement a drop of the film-forming material dissolved in benzine was placed upon the water surface S, the benzine allowed to evaporate and the pressure of the remaining film measured by turning the torsion head to exactly counterbalance the pressure of the film against the barrier. During the time benzine was still present in the water surface, the barrier had to be clamped owing to the high pressure this solvent gave until it had evaporated.

A further barrier and a long screw served to vary the effective surface S without the removal of the glass case ABCD.

It is important to notice that on account of the low pressures for which measurements were required, the barrier TT′ could not be allowed to make actual contact with the sides of the hollow rectangle. However, the apparatus was so constructed that the clearance at each end was only 1·5 mm. By observation of the movement of particles of lycopodium powder scattered upon the water surface, Marcelin reached the conclusion that no appreciable leak occurred, except for high pressures of the film, and accordingly he neglected any leak which might have taken place.

It seemed possible that one of these methods employed by Marcelin for his measurements of the pressures of the films upon a water surface might well be applicable to the study of the pressures of spreading films upon a mercury surface.

In the first place, a strip of thin steel spring bent to the shape of an ellipse was used after the manner of Marcelin's aneroid barometer type of apparatus. The ellipse was allowed to float upon the mercury surface, one side being held steady in a clamp while the other side was observed by means of a tele-microscope when a drop of solution was placed upon the mercury within the ellipse. It was

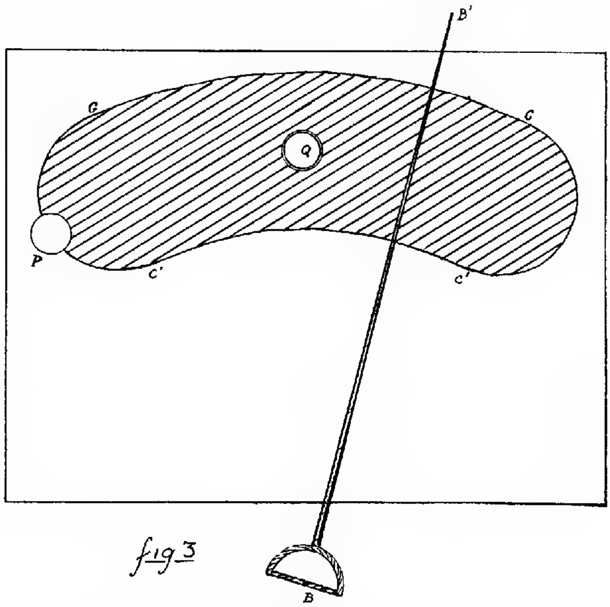

fig 3

hoped that a movement of this side of the elliptical enclosure would be observed and serve as a measure of the pressure exerted by the spreading drop, but the apparatus was apparently not sufficiently sensitive and no movement whatever was detected.

A second apparatus of a similar type was also tried. In this a strip of thin platinum ribbon was joined to a glass frame to make the fourth side of an apparatus similar to that used by Marcelin (fig. 1), the platinum ribbon replacing the mica strip in his experiments. However, it was found that the platinum ribbon was always pulled down flat on to the mercury surface, in which position the apparatus became insufficiently sensitive for any accurate measurement. Coating the ribbon with shellac by dipping it into a solution of this substance in alcohol did not, so far as could be observed, affect the spread of the drop of

solution upon the mercury, and this prevented amalgamation between the platinum and the latter. Even so, however, it did not completely do away with the tendency of the ribbon to lie flat upon the surface, while a fresh difficulty now appeared. The spreading drop of acid or salt solution spread readily beneath the platinum ribbon at various points, rendering measurement of the pressure impossible.

Finally an apparatus similar to that employed by Marcelin for work at low pressures was devised, and this was used to take all the measurements recorded in this paper.

A piece of thick plate glass had a hollow depression ground upon one surface of the shape of the shaded portion in fig. 3. Clean mercury could be forced upward through a tube which passed through the glass plate at Q, and would then overflow, filling the depressed portion of the plate. This depression was sufficiently shallow to ensure that the upper surface of the large drop of mercury so formed would always be about 2 mm. above the surface of the remainder of the glass plate. Both CC and C′C′ are arcs of circles having their centres at B. A thin glass barrier BB′ was pivoted at B and supported by a fine torsion wire of phosphor-bronze in such a manner that the end B′ could be raised or lowered vertically while movement in a horizontal plane was opposed by the elastic forces of the torsion wire. It was found that, a drop of mercury having been formed and the barrier lowered until one end floated upon its surface, the pressure exerted

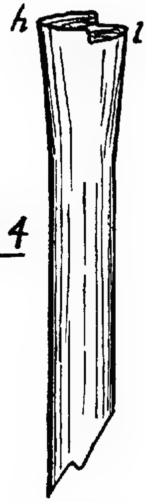

fig 4

by a spreading drop of dilute acid could readily be demonstrated by the movement of the glass barrier.

It appeared that freshly-formed drops of mercury showed little trace of a tendency to adhere to the ground glass surface of the barrier, but on the other hand, after the latter had remained some time in contact with the mercury, considerable adhesion was noticeable. The shape of the depression in which the drop was formed was, therefore, so chosen that the same portion and the same length of the barrier would remain in contact with the drop of mercury for small movements of the glass rod from its mean position. (In view of the experience gained during the use of this torsion balance, however, this precaution does not seem to have been really necessary.)

The mercury was passed from the depression after a reading had been taken by means of a second glass tube which had been ground to fit a coned hole in the

glass plate at the point P (fig. 3). This tube had been cut away at one side as shown in fig. 4, so that, when the lower side l was turned toward the mercury the liquid could flow freely down the tube, carrying upon its surface the acid solution, while the mercury could be retained in the dish if the side h of the tube was turned toward the depression. Thus the dish could be emptied by turning the glass tube through 180°.

Fig. 5 represents the apparatus in its final form.

The torsion wire, TT′ of 34 gauge phosphor-bronze wire and about 48 centimetres in length, had a torsion head attached and a graduated scale and pointer at T. P represents the thick glass plate, BB′ the glass barrier, while the tube by which the mercury is drawn off is shown at E. Clean mercury is poured into the wide tube R, and is led along AA until a sufficient quantity has overflowed from the inlet at the centre of the glass plate to fill the depression in it. The plate P rested upon a sheet of plate glass 35 cm. in diameter, upon which fitted the cylindrical glass cover CCCC which served to encase the apparatus. The sheet

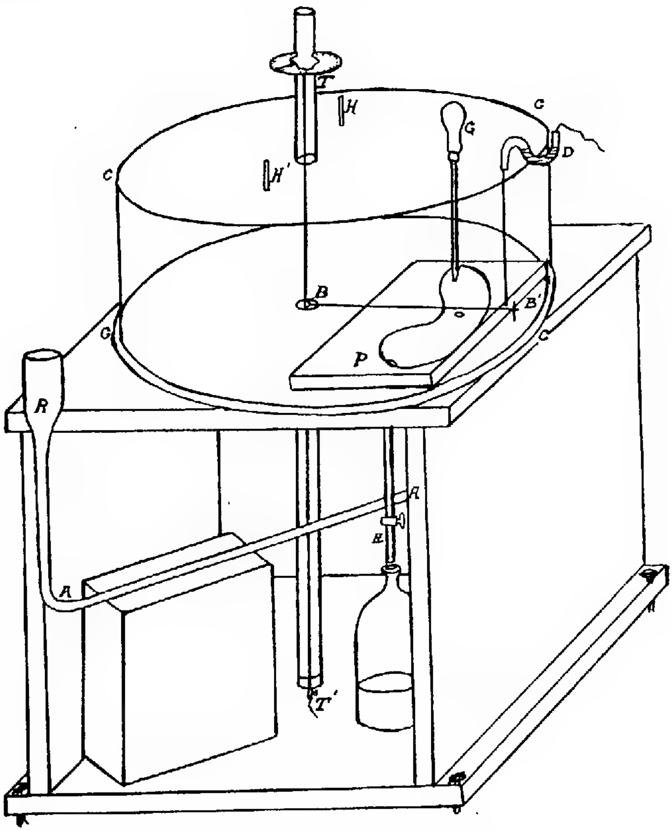

Fig. 5.

of plate glass and the glass cover of the apparatus were ground to fit closely, and the joint between them was smeared with rubber grease. It had been found that this substance did not give off sufficient vapour to affect the cleanliness of the mercury surface, if care were taken that no actual contact occurred between the grease and the mercury. A fine thread attached to the barrier at B′ passed out through a mercury seal at D, and served to raise or lower the barrier. A pipette G, passing through the upper side of the case, was used to place drops of solution

upon the mercury surface. Two further tubes HH′ served to draw dry air through the apparatus. A tap was sealed to the outlet tube E in order to prevent air from entering the apparatus at this point. This tap had of necessity to be left ungreased in order to avoid contamination of the mercury; and the ground glass joints of the tubes where the mercury entered and left the case were likewise necessarily left without grease, but apart from these joints each tube which entered the case was sealed to it either with hard sealing wax or by means of a ground glass joint and rubber grease. It was hoped, in this way, to obtain an atmosphere free from water vapour within the case. The whole apparatus was fitted with levelling screws.

Burdon *(loc. cit.)* drew attention to the fact that neither the slow-spreading drop of water nor the fast-moving acid or salt-solution was able to spread over the curved surface at the edge of the mercury in the dish. In the present experiments, however, considerable difficulty has in certain cases been encountered, owing to the fact that acid solutions in almost every instance, and occasionally pure water also, have been found to pass the curved edge, leaving the dish wet when the mercury was poured away. However, only very slight traces of the solution usually reached the dish, the bulk of the latter liquid being carried away upon the surface of the mercury; so that it has been found sufficient in most cases to merely allow the dish to dry, when, upon washing it out once or twice with clean mercury, further readings could be taken. In a few cases, when dealing with less volatile acids such as sulphuric or even nitric, the acid molecules remaining on the dish were sufficient to render later readings uncertain unless a considerable time were allowed to elapse after the dish had become dry. On the other hand, this difficulty was not met with when using such acids as hydrochloric, nor did it occur when salt solutions were being used. In these two cases the dryness of the dish was sufficient to indicate when a further reading could be taken.

It was hoped that the floating barrier, by sinking in the mercury and causing a depression of its surface, would act in exactly the same manner as the edge of a dish and practically prevent the spread of the acid beyond it. It was soon found, however, that this was not the case, and an acid solution or even distilled water spread readily past the barrier. In every instance this occurred merely at the ends of the barrier, and in no case has there been observed such a leak, except at these points. All attempts to prevent this leak proved futile. The barrier was ground to a V-shape in an attempt to render the curvature of the mercury surface more pronounced than was the case for the circular glass rod previously used in this connection. Weighting the barrier and depressing it more deeply in the mercury produced no effect whatsoever upon the leak, until the barrier was forced to the bottom of the dish, when the drop of mercury within it became completely divided into two.

It was impossible, therefore, to use the apparently obvious procedure of placing a drop of solution upon the mercury surface and turning the torsion head until equilibrium was obtained. The following method has consequently been used for measuring the *instantaneous* spreading pressures.

Fixed to the glass dish near the end B′ of the barrier (fig. 5) was an upright glass rod. To obtain a reading, the point was found to which the torsion head had to be turned in order to allow the barrier to float upon the mercury surface, almost making contact with this fixed rod. The torsion head was now turned through perhaps 70 degrees, so that the barrier was pressing firmly against the glass upright, and a drop of the solution to be tested was placed upon the mercury surface, so that the force exerted by the spreading drop would oppose the twist of the torsion wire. The mercury was poured out and fresh mercury introduced, the torsion head turned to, say, 60 degrees, and the procedure repeated until

finally a torsion was found at which the spreading drop would just move the barrier very slightly. By this method of trial and error it was possible to find the force exerted by the spreading drop. The assumption is made that, on account of the rapidity with which the reading was taken, no leak had taken place before the barrier began to move. Reference will be made presently to the justification for this assumption.

It should be emphasised that the method has the distinct disadvantage that it measures merely the pressure at one particular instant during the spreading of the drop upon the mercury surface, that is, at the time when this pressure has reached a maximum. Thus the method will not serve to show whether this pressure would be maintained for a period if no leak occurred, and, if so, for what duration of time. The rate at which the barrier returns to its original position after being driven off through twenty or thirty degrees by a spreading drop of solution does indeed show that some pressure is maintained for at least a few seconds after the solution has ceased to spread; but, in the absence of any method of measuring the leak past the barrier, this does not afford any quantitative measure of the "static" pressure of the drop.

The criticism by Adam and Jessop *(loc. cit.)* of the apparatus and experimental methods of Marcelin in measuring the pressures of the films upon a water surface, was levelled chiefly against the insufficient precautions taken to secure absolute cleanliness and the purity of materials used, and against the insufficient precautions taken to overcome leak past the barrier. In view of the apparently unreliable results obtained by Marcelin and the similarity of his apparatus to the one here employed, particular attention has been directed toward eliminating errors from the sources mentioned. Marcelin, in testing for leakage past the barrier, used lycopodium powder scattered upon the water surface, and since no motion of these particles was observable at low pressures of the film, concluded that any leak which did occur was negligible. In a similar test upon a mercury surface no trace of leak has been observed until the acid drop itself has begun to spread past the barrier, when, of course, the particles receive a slight displacement. If, however, as seems probable, a thin film of water vapour is already present upon the mercury surface before the drop of solution is placed upon it, then the movement of the lycopodium particles certainly represents an insufficient criterion of compressions and movements of this film, and little reliance has been placed upon this effect as proving the non-existence of a leakage past the barrier. By adopting the experimental method previously described, however, it appears that the loss of pressure owing to leakage during the taking of a reading is made sufficiently small for it to be neglected without introducing serious error.

In no case when a reading has been taken has the time which elapsed between the instant at which the drop of solution reached the mercury surface, and that at which the critical movement of the barrier occurred, been of more than one second's duration. Now, by allowing the barrier to be pushed off through a certain distance by a spreading drop of solution and measuring the time taken for it to recover its initial position, some idea of the rate at which leak occurs may be obtained. It was found that an initial reading of pressure of about four dynes per cm. fell at the end of fifteen seconds to zero, and since the movement of the barrier back to its initial position was a steady and uniform one, the rate of the leak was probably also approximately constant. On the other hand, with an initial pressure of twenty dynes per cm., which is of the order usually recorded in these experiments, it was found that a leak occurred equivalent to about one dyne per cm. per second. No attempt has been made in the measurements recorded in this paper to make an allowance for the leak past the barrier even at higher pressures, chiefly owing to the difficulty of estimating the fraction of time during

which leak takes place before the maximum pressure is recorded. As stated above, this time is certainly not greater than one second in any case; and it may be considerably smaller since leak can only occur at the ends of the barrier, and these ends are the last portions of the rod to be reached by the spreading drop. If, therefore, as seems not improbable, little leak occurs until the drop of solution itself approaches the barrier, the maximum pressure against the rod may occur almost exactly at the instant when leak begins. Whether this latter is the case or not, however, there seems every reason for concluding that no serious error is introduced in neglecting any slight losses of pressure from this source.

In these experiments the same precautions have been taken for cleaning the glassware and the mercury as those recorded in the paper by Burdon *(loc. cit.)*. The mercury was cleaned by distillation in a hard glass still under reduced pressure in a slow current of air, then shaken with strong sulphuric acid containing a few crystals of potassium bichromate, washed thoroughly in distilled water and dried. In the first instance the spread of a drop of distilled water upon the surface of the mercury was used as a test of its purity and freedom from grease contamination, etc. This test, however, in spite of its extreme sensitiveness to any contamination upon the metal surface, was found to be insufficient, and another test was always used in actual practice before and after taking a set of the measurements recorded in this paper. This test consisted merely in measuring the pressure exerted by a drop of acetic acid solution, concentration one-hundredth molar. Under the very best conditions for spreading this gave, it was found a pressure of 17 dynes per cm., when the drop of solution was applied to the mercury surface 30 seconds after the latter had been poured in the dish. In practice all readings were disregarded if the two test readings with the acetic acid solution failed to comply with this standard. The reasons for adopting this particular solution and concentration as the standard one, will appear later.

Only glassware was allowed to come into contact with the mercury, and all parts which did so were first carefully cleaned by first immersing in sulphuric acid containing a few crystals of potassium bichromate, then washing with distilled water, and drying. There appears to be no reason for attempting to obtain very pure substances for forming the solutions, drops of which were to be applied to the mercury surface, and ordinary chemically pure acids and salts have been used throughout.

The torsion wire of the apparatus was calibrated by measuring the amount of twist of the torsion head necessary to counterbalance a known torsion. It was found that one degree of the torsion head was equivalent to a two dimensional "pressure" of ·22 dynes per cm. upon the mercury surface. The drop of solution given by the pipette used was found to be ·03 c.c. in volume. Various tests were made of the amount of solution in a drop from the pipette under differing conditions, and it was shown that the volume of the drop never varied by 3% from the mean value quoted above.

III. Variations in Conditions of Spreading.

In observing the spread of an acid upon a clean mercury surface exposed to the air, it quickly became apparent that inconsistent results were being obtained upon different days, which could not be explained merely by assuming that the mercury had become contaminated. Thus, in an extreme case upon a cold day, it was sometimes found that fairly dilute acid would show little tendency to spread upon a freshly-poured mercury surface, while the same mercury, washed in distilled water but otherwise untreated, would often allow even distilled water to spread upon its surface when poured in the same dish a few days later. It was found that warming the dish often caused a very marked improvement in the

conditions of spread, and the thought immediately suggested itself that the variation of the spreading was due to a variation of the amount of water-vapour which had condensed upon the mercury surface from the air in the form of an adsorbed layer. Accordingly the apparatus was enclosed as described in the large glass cover and dry air was drawn through the apparatus. Whether because of the fact that a minute leak of moist air could not be prevented, or whether from some other cause, very little improvement in the reliability of the readings was observed. Burdon and Oliphant,[9] however, who have observed various phenomena of the spread of liquids upon a mercury surface within a perfectly air-tight case, appear to have rendered their measurements perfectly reproducible by taking care that only dry air should be admitted to the case. There appear to be then, only two possible explanations of the discrepancies found at various times. In the first place it may be that owing to the ground-glass joints at the points where the mercury enters and leaves the apparatus, sufficient air entered the glass cover at these points to give a humidity high enough to affect the results. Without a reconstruction of the whole apparatus it would have been impossible to completely prevent leakage at this point. It would appear, however, that this cause is in itself insufficient to bring about the changes described, since attempts made to render the readings more consistent by *forcing* dry air into the apparatus and thus maintaining a pressure slightly greater than atmospheric within the case met with little success. There still remains the second possibility that a sufficient evaporation takes place from the drop of solution from the end of the dropping pipette to cause discordant results. If a monomolecular film of water vapour is all that is necessary to bring about the variations mentioned, then evaporation from the pipette may well be the cause of the whole difficulty. A possible explanation from some other cause has been sought, such as a contamination of the mercury surface by the dust or carbon dioxide of the air, or by small bubbles of water carried with the mercury into the apparatus from the separating funnel in which the mercury was washed. Upon examination, however, none of these explanations have appeared tenable. Moreover, if we may accept the validity of the results of Iredale,[10] in his experiments upon the adsorption of water at a mercury surface, the hypothesis that the fluctuations are due largely to a condensation of water vapour upon the mercury in the dish would appear very probable. The work of this experimenter was, of course, carried out by means of the "drop-weight" method of measuring surface tension, and the evidence adduced by Burdon and Oliphant throws some doubt upon the applicability of this method to determinations with mercury. Nevertheless, there seems little reason to question the fact that Iredale's results are at least relatively correct, even if the absolute values obtained by that experimenter should prove unreliable.

Further evidence for the conclusion that a film of water-vapour is responsible for the fluctuations which have occurred from day to day will be given later, when the relation between the spreading pressure and the time that the mercury has been poured is discussed.

Mention may be made here, however, of similar inconsistencies occasionally encountered by Gouy[11] when carrying out measurements of the fall of surface-tension of a mercury surface in contact with various solutions. Gouy used the reliable "big drop" method, and found that his measurements had to be taken fairly quickly on account of the fact that the interfacial tension fell rapidly after contact of the mercury and solution for a short time. In the case of certain solutions it was found impossible to take readings at all, owing to the extreme rapidity

(9) Burdon and Oliphant, Far. Soc. Trans., xxiii., 3, 1927, pp. 205-213.

(10) Iredale, Phil. Mag., xlv., 1923, p. 1088; xlviii., 1924, p. 177.

(11) Gouy, Ann. de Phys. vi., Ser. 9, 5, 1916.

with which the interfacial tension fell off after the large drop was formed. In some instances, however, when dealing with solutions upon which measurement was usually possible, an occasional reading showed a large variation from the value of others of a series, and the discrepancy was far too large to be regarded as merely due to the inaccuracy of the measurement. The cause of these occasional erratic readings does not appear to have been traced, but they may possibly have been due to movements of the solution being experimented with, which have caused an irregular adsorption of the molecules of the solute. These examples of irregular behaviour would thus correspond fairly closely with those recorded in this paper.

Now, while the pressures recorded for one solution have been found to vary considerably from the value found upon any given day, yet the results obtained upon one particular day have been, in almost all cases, remarkably consistent among themselves and seldom varied by more than a few per cent. from one observed value. Therefore, since the test already mentioned (Acetic Acid 1/100th molar solution to give a pressure of 17 dynes per cm.) has been applied whenever readings have been taken, and all measurements discarded when these conditions of spreading were not fulfilled, it is believed that, in spite of the inconsistencies which have occurred upon many occasions, only those readings have been accepted, during the taking of which the controlling conditions have been identical and most favourable to spreading. Probably, in these cases, the amount of water-vapour in the air was sufficiently small or the evaporation of the adsorbed film from the mercury sufficiently rapid for the remaining molecules to be practically ineffective in preventing spreading. There seems no reason why the adsorbed water-vapour film should be the only factor which tends to prevent spreading. An adsorption of other molecules—*e.g.*, the nitrogen and oxygen of the air—probably occurs also at the surface of the mercury, and this adsorption may also play a part in determining the tendency for spread to occur. Indeed, although the complete interpretation of the phenomena described by Popesco(12) in his paper upon the surface-tension of mercury in vacuo, and in the presence of various gases, may differ widely from that given by him, yet it seems probable that the complete explanation must take into account some adsorption of gases and vapours at the mercury surface.

IV. Variation of Pressure with the Time the Mercury has been Poured.

If the mercury was allowed to stand in the dish for a few minutes after being poured before the drop of solution was placed upon it, then it was found that the pressure which the spreading solution exerted was considerably smaller than the pressure given by a drop spreading upon a freshly-poured mercury surface. If the pressure exerted is plotted against the time the mercury has been allowed to stand before the drop of solution is placed upon it, then curves of the type given in fig. 6 are obtained. Tables I. and II. give the data from which these curves have been drawn. It is observed that in the case of the spreading of the sulphuric acid solution a test-reading with acetic acid was not taken, and it is believed, therefore, that the time-values are only a fraction of those which might have been obtained under other conditions, although quite consistent in themselves. This question will be discussed later.

(12) Popesco, Ann. de Phys. 10th Ser. 3, 1925, p. 402.

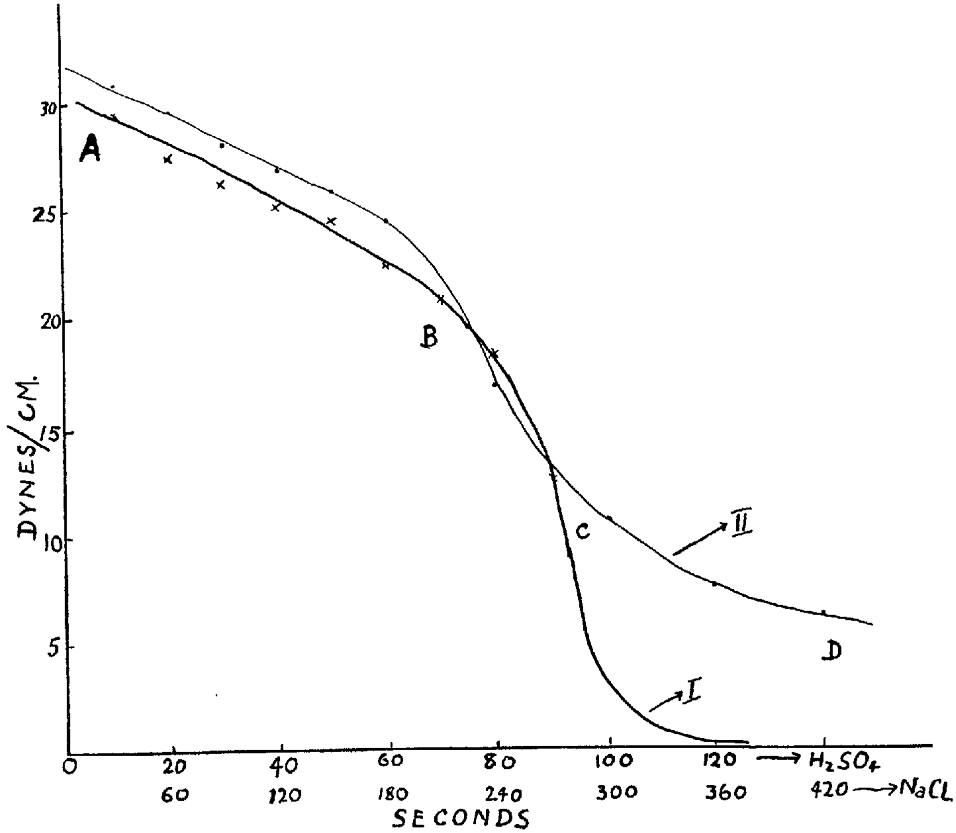

Fig. 6.

Spreading Pressure against Time for:—

I. Sulphuric Acid — 1/50 Molar, and II. Sodium Chloride — Molar.

VARIATION OF SURFACE TENSION OF MERCURY WITH TIME (POPESCO).

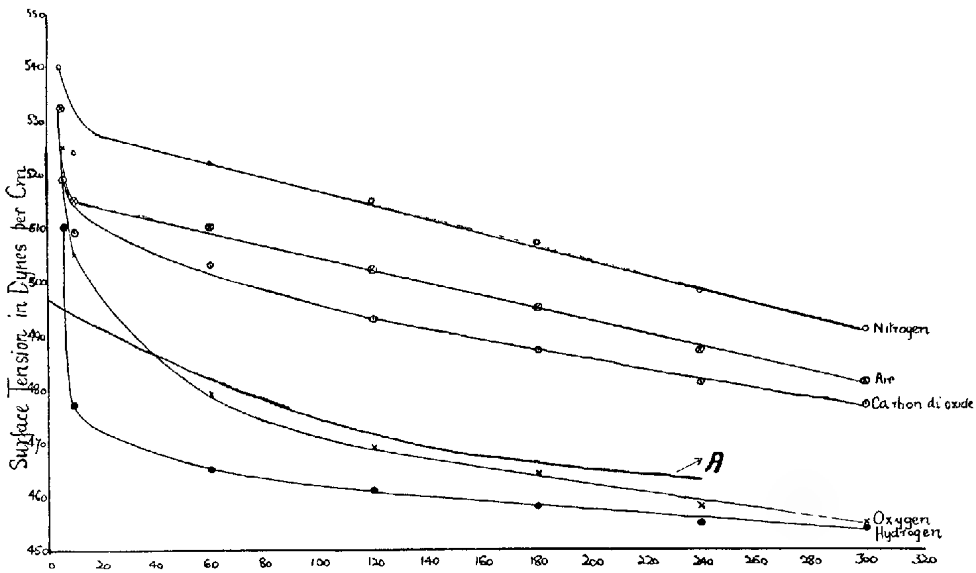

Fig. 7.

Time in Seconds.

TABLE I.

(t = time in seconds which the mercury has remained in the dish before the drop of acid was applied; p = pressure exerted by spreading drop in dynes per centimetre.)

Solution of concentration 1/50th molar; temperature 22°C.

t	p
5	30·3
10	29·6
15	30·8
20	28·0
25	26·9
30	26·3
35	25·1
40	25·1
45	25·1
50	24·7
55	24·1
60	22·5
65	21·8
70	20·6
75	19·6
80	18·4
85	14·6
90	12·3
95	4·4
100	2·2
120	$<$ 2·2 but slow spread still occurs

TABLE II.

Molar solution of sodium chloride, temperature 17°C.

Test reading with acetic 1/100th molar gives p = 17 dynes per cm.

t	p
30	31·2
60	29·6
90	28·2
120	27·1
150	26·0
180	24·7
240	17·0
300	10·8
360	7·4
420	6·2
480	4·4

Exactly similar curves have been obtained with every solution tested: sulphuric acid, nitric acid, acetic acid, and hydrochloric acid of concentrations varying from molar to 1/1000th molar, and also with a molar solution of sodium chloride. Each curve shows the three characteristic portions, AB, BC, CD. Now, the inconsistency of the readings referred to in the previous pages is most clearly marked in the consideration of these pressure-time curves. Whereas it was comparatively easy to reproduce on successive days the readings for the pressure of a drop placed upon the mercury shortly after it had been poured, yet considerable variation would still be observed for the pressures upon a mercury surface which had stood for some time before the drop was placed upon it. It was observed, in fact, that upon different days the curves were of exactly similar type and could be brought into complete agreement with one another if all the time ordinates upon a curve were multiplied by a constant factor. Now, this is exactly what might be expected if the whole cause of the variation were to be sought in the condensation of a film of water-vapour upon the mercury surface. For, if an adsorption is the cause of the decreasing spreading pressures, then the actual decrease of the latter will be an exact measure of the resistance offered by the adsorbed film. Now, the work of the many experimenters upon the fatty-acid films upon water has given abundant evidence of the sudden increase of resistance to spreading which occurs as soon as sufficient molecules are present to give a monomolecular adsorbed film. It appears justifiable, then, to regard the explanation of the upper portions of these pressure-time curves as follows. During the time represented by the portion AB a monomolecular adsorbed film is in the process of formation, and this offers a slight resistance to spreading. By the time represented by B, however, so large a fraction of the surface is covered with adsorbed molecules of water, that when the film is suddenly compressed by the spreading drop a monomolecular film is formed upon the far side of the barrier, which film can oppose quite a large resistance to any movement of the latter. Consequently the pressures recorded decrease very rapidly from this point onward.

Moreover, if the falling off of the pressures along the portion AB is due to the resistance to spreading offered by a film of water-vapour, then the difference of the pressures between A and B should be the same in every case and should be equal to the maximum pressure which can be exerted by a film of water-vapour adsorbed at a mercury surface while the film is still in a state corresponding to the "expanded" films of Langmuir and Adam. This difference of pressure should then be quite independent of the acid or salt employed. Now, in every curve obtained, although the total pressures at A vary from as much as 60 dynes per cm. down to about 20, and although the time represented by B varies from 20 seconds to as much as two minutes, yet this difference of pressure upon any one curve is constant within the limits of experimental error and equal to about 8 dynes per cm.

It seems very probable, therefore, that as a monomolecular film is formed upon the surface of the mercury, the effective spreading pressure of the solution decreases owing to its having to overcome a pressure exerted by the vapour film. It is to be expected that the resistance offered by the latter will be approximately proportional to the number of molecules present in the film, and this is shown in the linear decrease of the effective pressure which is actually observed along the curves from A to B. Finally, when the monomolecular vapour film has been completed, the pressure which it can exert increases far more rapidly than before, and causes the steeper slope of the curves from B to C.

These conclusions are in good accord with those expressed by Iredale *(loc. cit.)*. It is to be remarked, however, that there appears little justification for Iredale's assumption that the films increase to become more than one molecule thick. The varying values obtained in his experiments for the surface-tension of

mercury after a certain vapour-pressure has been reached would appear to be exactly analogous to the varying pressures at which the resistance to compression of the fatty acid films breaks down. Adam has shown that the pressure required to break down a film is quite indeterminate (Proc. Roy. Soc., vol. A 99, pp. 348 and 349), and the indeterminate results obtained by Iredale would appear to be capable of an exactly similar interpretation, the adsorbed film of vapour in his experiments replacing that of the fatty acids in Adam's work. Thus, it is only necessary to suppose that the adsorbed film is capable of exerting a pressure which is not in all cases the same owing to mechanical vibrations, dust particles, etc., and a complete explanation of the whole phenomenon is to hand without having recourse to hypothetical films several molecules thick. If Iredale's explanation were the correct one, then it would be necessary to suppose that the adsorption of the first layer of molecules caused a decrease of surface tension of the mercury of 60 dynes per cm. in the case of methyl acetate and 25 dynes per cm. for water, while the adsorption of further layers produced a further lowering of surface tension in these two cases of 42 and 79 dynes per cm. respectively. Now, all our present knowledge of surface-tension phenomena would appear to point to the conclusion that the layer of molecules immediately at a surface, or the two layers on either side of an interface, contribute by far the greater portion of the forces which manifest themselves in surface-tension phenomena, and it appears scarcely conceivable that the first adsorbed layer of water-molecules could lower the surface tension by only 25 dynes per cm. while further layers give a further decrease of 79 dynes per cm. Moreover, there is no other evidence from other sources to justify Iredale's assumption. It should be observed that the portions of the curves given by Iredale relating to higher vapour pressures are purely hypothetical and not based upon actual measurements. (Fig. 3, p. 1098, Phil. Mag., vol. xlv., etc. *Vide* also discussion on page 1099 of the same paper.)

It is true that with the comparatively high vapour-pressures employed by Iredale in his experiments, it might be expected that a complete adsorbed film would be formed very rapidly indeed. However, as Burdon and Oliphant have pointed out, the drop-weight method used by Iredale is almost certainly not a purely static one, no matter how slowly the drops may be formed; and thus, in practice, varying amounts of adsorption may be expected to determine the surface-tension when the vapour-pressure within the apparatus is varied.

The theory outlined above appears also to offer an explanation of many of the phenomena of spreading described by Burdon. Thus, if a drop of water is placed upon a mercury surface upon which a film of water-vapour is condensed, then it is to be expected that the spreading of the drop will be opposed by the pressure which the film can exert. If now the tendency of the drop to spread (in this case possibly a mere gravitational effect) is of the order of a few dynes per cm., then this pressure will be insufficient to do more than merely compress the water-vapour film very slightly upon the remainder of the mercury surface. Now, it is well known that if upon a clean water surface is placed a greater quantity of certain substances than is required to form a monomolecular layer, then the excess material is drawn up into drops upon the surface while the remainder forms a film one molecule thick. If a pressure is now applied at the edge of this film the area covered by it will be reduced, some of the film molecules passing into the drops upon the surface. An exactly similar phenomenon probably occurs upon a mercury surface upon which a drop of water is spreading. If it is imagined that a drop of water has the power to exert a very slight pressure against the surrounding film, then a gradual adsorption of the film molecules which are in immediate contact with the drop of water will occur. Consequently, the number of molecules in the adsorbed film being decreased, its resistance falls and a gradual spreading occurs. The presence of more than one drop of water upon the same mercury surface will make practically no difference to the spread of either.

Moreover, Burdon and Oliphant have pointed out that the rate at which the diameter grows appears to increase with time. If the theory here given is correct, and the pressure exerted by the drop against the film may be regarded as constant over some period of time, then the increase in area will be proportional to the circumference of the drop at any instant, since this will determine the rate at which the adsorbed film molecules are taken up by the drop. This would, of course, agree well with experiment and observation.

There are two methods by which the drop of water may maintain its pressure against the adsorbed film. In the first place, if the water is not absolutely pure an adsorption of dissolved substances may take place at the mercury-water interface which will lower the interfacial tension. This, of course, would simply be equivalent to giving the drop a tendency to spread. In the second place, the weight of the drop will itself cause a pressure against the film molecules. If the depth of the drop of water is 1 mm., then the hydrostatic pressure will be 98 dynes per sq. cm. The force, then, which the drop can exert against a row of molecules in the adsorbed film one cm. long will, therefore, be of the order of $3 \times 10^{-8} \times 98 = 2{\cdot}94 \times 10^{-6}$ dynes (taking the diameter of the molecule as 3×10^{-8} cm.). Thus, in accordance with this very rough calculation, the spreading pressure of the drop due to its gravitational energy alone may be taken as equivalent to a surface tension effect of the order of 10^{-6} dynes per cm. It seems rather doubtful whether this would be sufficient to cause even the slow spread described by Burdon for high-grade conductivity water, and even in the case of very pure water slight traces of dissolved substances adsorbed at the interface may aid the spreading.

In the case of a drop of water placed upon a mercury surface in the presence of moist air, the slow rate at which the drop can take up molecules from the adsorbed film may be less than the rate of condensation of other molecules from the gas, so that in the presence of large quantities of water-vapour in the air no spreading will occur. This has, in fact, been observed.

A further fact noted by Burdon now becomes clear. It was observed that a grease contamination of about 1/10th that required to form a monomolecular layer, was quite sufficient to prevent drops of water from spreading over a mercury surface. Under all the ordinary views on the subject it is extremely difficult to see how this amount of grease could so markedly affect spreading, although it would be clear that the amount which gives a monomolecular layer might well do so. It is clear, however, from the excessive rapidity with which mercury can take up grease contamination, that the forces of attraction on the grease-molecules at a mercury surface are even more powerful than at the surface of water. Consequently, if a drop of water is placed upon a mercury surface contaminated with even the amount of grease required to give 1/10th of a monomolecular layer, then, as the drop of water spreads ever so lightly, it will come into contact with grease molecules which, however, cannot be absorbed by it, and which soon form a protective ring at the edge of the drop and prevent the absorption even of the water molecules of the adsorbed film. Thus the resistance of the surrounding film is maintained and spreading cannot occur.

In the presence of dry air, however, and with a perfectly clean mercury surface, the drop may spread right up to, and over, the edge of the mercury, and this behaviour has been observed by Burdon and Oliphant. Moreover, if the gravitational energy of the drop is the chief cause of spreading, the movement will always occur from the centre outwards, as required by the same experimenters.

As the spreading drop increases greatly in area, however, the forces tending to cause further spreading will diminish, and this for several reasons:—

1. The gravitational energy of the drop is decreasing.
2. Such adsorption of dissolved molecules as has occurred at the interface will be less effective owing to the increased area per adsorbed molecule.

3. Evaporation of water from the drop will increase the vapour-pressure and consequently increase the rate at which molecules are being adsorbed at the rest of the mercury surface.

Following upon spreading, therefore, a condition may sometimes be reached in which the drop remains stationary for a time, and then even commences to contract once more, as may be shown experimentally. Moreover, if a drop of mercury is poured in fairly dry air and a drop of water placed upon the surface before a large fraction of the surface has had time to adsorb a unimolecular layer, a much more rapid and complete spreading of the water is to be expected than would take place if the mercury had stood for a short period in the dish. This effect has often been noticed, and the spread of the drop of water in this case proceeds at very many times the rate at which it spreads after the mercury has stood for even 30 seconds. Following closely upon this rapid expansion a much slower contraction almost always occurs, as the drop is compressed by the slowly-forming adsorbed film.

Still further support for the theory is lent by the observation that water spreading upon mercury in the peculiarly-shaped dish used in these experiments does not spread as a circular drop, but with a tendency to conform to the shape of the dish. This is particularly the case when the spreading is more rapid, when any viscous forces in the adsorbed film are necessarily more effective.

In none of the experiments of this paper has the barrier been wetted by spreading drops of solution, although pressures as high as 108 dynes per cm. have been recorded. In view of this, and the other evidence given above, it is difficult to avoid the assumption, therefore, that an adsorbed film is formed upon a mercury surface in the presence of air which is capable of sustaining, for a brief period, lateral pressures as high as 100 dynes per cm., but which, nevertheless, gives way exceedingly slowly to such pressures as those exerted by a spreading drop of water where the spreading pressure is almost certainly less than 4 dynes per cm. The theory given above is capable of giving a fairly complete explanation of the facts, and it is difficult to see any other means by which the same effects could be produced.

A similar explanation should be sought for the case of an acid or salt solution spreading upon the mercury surface. Here, indeed, an extremely rapid adsorption of the acid ions or molecules at the interface between the mercury and the solution takes place. On account of the much greater affinity of the mercury atoms for these molecules and the consequently greater loss of free energy at the interface, the tendency of the drop to spread will be considerably greater than in the previous case, and usually exceeds the pressures exerted by the adsorbed films. Now, in this case two separate causes may finally prevent rapid spread. If the adsorbed film has not had sufficient time to form completely, and if the acid is very dilute (of the order of 1/10,000th molar), then rapid spread will cease after the manner described by Burdon when the adsorbed acid molecules are spread over a sufficiently large area for their effect upon the surface tension to be insufficient to overcome the pressure of the surrounding adsorbed film. The area covered by the rapidly-spreading acid will thus be of the same order, whatever the acid used, but will have no direct relation to the presence, or otherwise, of a monomolecular film at the interface. On the other hand, if the adsorbed film has been allowed to form sufficiently to resist the full pressure which the acid can exert, then no rapid spread will occur. In both this case, however, and in that where the drop ceases to spread rapidly owing to the complete adsorption of the acid molecules, a further slow spread will be possible owing to the taking up of the adsorbed molecules by the drop of acid. Thus, in the pressure-time curves described earlier, although no appreciable pressure could be recorded in many cases along the

portion CD of the curves, it was evident from the fact that slow spreading still occurred, that some pressure was being exerted by the drops of solution.

A similar phenomenon is evidenced by the spread of a drop of acid upon a mercury surface upon which one drop has already spread and evaporated. In this case the second drop will remain sometimes for a period of several minutes without showing the slightest tendency to spread, but finally expands slowly across the mercury. No doubt adsorption occurred here when the first drop spread, but under the pressure of the second drop of solution much of the adsorbed film was taken up by it until the drop of acid was able to spread slowly. It seems possible that most of the phenomena of expansion and contraction of certain films upon a mercury surface may be explained after a similar fashion, the very slight increase in evaporation of the film in the expanded state serving to just increase the adsorption at the remainder of the mercury surface sufficiently to cause contraction. Then, the vapour-pressure falling very slightly, the adsorbed molecules will be taken up by the drop of solution more rapidly than condensation of others can occur at the mercury surface and a further expansion will occur. In this way the whole cycle may be repeated quite a number of times. Now, while it might be possible for slow contractions and expansions of this type to take place with any solutions, yet only those which can exert a pressure of several dynes per cm. will be capable of rapid alternations of expansion and contraction. For if the adsorbed film is in equilibrium with a solution which is exerting a high spreading pressure, then the adsorbed molecules must be already in the state of the "compressed films" of Adam and Langmuir. Consequently the adsorption of comparatively few more molecules will increase by a large amount the pressure that the film can resist, and the expansion and contraction of the drop will likewise occur comparatively rapidly. In actual experience, rapid alternate expansions and contractions have been observed only in the case of moderately concentrated solutions.

V. The Problem of the Surface-Tension of Mercury.

In considering the spreading of a liquid upon a mercury surface after various periods of exposure of the latter to a gas, Burdon and Oliphant have pointed out the apparent contradiction of Antonow's Rule in the case in which water spreads upon a mercury surface whose surface-tension is very much less than 500 dynes per centimetre. The explanation proposed by these workers is, that spreading always occurs from the centre of the drop of water where a freshly-prepared surface is available. Whether this is so or not, however, the pressure which the spreading drop must exert in order to spread at all must—from this standpoint at least—clearly be sufficient to overcome whatever resistance is offered to spreading by the difference between the surface-tension of the mercury and the sum of the surface-tension of the water drop and the interfacial tension at the mercury-water interface. For, if within the drop a freshly renewed surface is being created, then in doing so work must be done, of which, for unit area of such surface created, the difference of surface-tensions of the new surface and the old is a measure. The explanation offered does not, therefore, give a very clear explanation of the phenomenon. A quite complete explanation of these observed facts, however, together with some insight as to what are the factors which cause the variation of surface-tension of mercury follow readily from a simple extension of the theory already outlined.

It will be necessary, first of all, to examine critically the theory proposed by Popesco to account for the phenomena described in his paper. It is certainly probable, as postulated by that experimenter, that an adsorption of gas-molecules occurs at the surface of a mercury drop formed in air. This adsorption, however, if it does occur, must almost certainly be completed within a period of time of an order not greater than a few seconds. For the vapour-pressure of mercury is, at

ordinary temperatures, of the order of 10^{-3} mm. Hence there must be present in the space above a mercury surface about

$$2{\cdot}7 \times 10^{19} \times \frac{1}{760} \times \frac{1}{10^3} = 3{\cdot}6 \times 10^{13}$$

atoms of mercury per cubic centimetre, since there are $2{\cdot}7 \times 10^{19}$ molecules of any gas in one cubic centimetre at atmospheric pressure. If we neglect, in a rough approximation, the Maxwell distribution of velocities and consider that one-sixth of these atoms are moving toward the mercury surface at any instant, each with a speed equal to $\sqrt{2/200}$ times that of a hydrogen molecule, then the number of atoms which strike one sq. cm. of mercury surface per second is:—

$$3{\cdot}6 \times 10^{13} \times \tfrac{1}{6} \times \sqrt{\frac{2}{200}} \times 1{\cdot}84 \times 10^5 = 11 \times 10^{16}$$

Now, since the density of mercury is 13·6 gm. per cc., the number of atoms in one c.c. of the liquid is given by:—

$$\frac{6{\cdot}06 \times 10^{23} \times 13{\cdot}6,}{200}$$

and taking the $\frac{2}{3}$ power of this, the approximate number of atoms of mercury present per sq. cm. of mercury surface $= 12 \times 10^{14}$.

According to Langmuir's theory of adsorption, every atom of mercury which strikes a mercury surface will condense there, evaporation taking place as a separate phenomenon. Consequently 11×10^{16} atoms of mercury enter each sq. cm. of surface per second, and since the liquid is in equilibrium with the vapour above, this must also be the number of atoms which evaporate. Taking into account the number of atoms per sq. cm. of surface, it is clear that the average time an atom of mercury remains in the surface is only of the order of 1/100th of a second. Now, it is exceedingly improbable that an adsorbed gas-molecule can remain in the adsorbed state at a mercury surface when the mercury atom to which it is attached evaporates. The conclusion appears inevitable, therefore, that the life of an adsorbed molecule upon the mercury surface cannot be greater than 1/100th second. There is, then, no reason why adsorption should slowly attain an equilibrium-value at the end of several hours, since, obviously, an entirely new cycle must be commenced after all the mercury atoms first present in the surface have been evaporated. Such adsorption as does occur, then, must take place with extreme rapidity, and the equilibrium-value, both of the amount adsorbed and of the surface tension, must be attained at the end of one second or less. Evidence from other experiments with adsorption at liquid surfaces entirely confirms this idea. Lenard[13] has made estimates of the rate of negative adsorption of cane sugar adsorbed at the surface of a solution in water, and finds that 95% of the adsorption has taken place within 10^{-8} seconds. Positive adsorption, while occurring considerably more slowly, takes only periods of from 1/100th second to one second. Hiss[14] carried out some apparently reliable measurements of the transition from dynamic to static surface tension of an aqueous solution of amyl acetate. The values found at a temperature of 14°C are:—

Time in seconds.	σ
0·0000	54·9
0·0047	45·7
0·0110	40·2
0·0189	36·6
∞	34·8

(13) Lenard, Sitzungsber. d. Akad. Heidelberg, 5, A, 1914, 28 Abh., p. 16, et seq.

(14) Hiss, Uber die zeitliche Anderung reiner Flussigkeitsoberflächen., Diss., Heidelberg, 1913.

It seems likely, then, that the time taken for adsorption of the gas-molecules at a mercury surface is of the same order as those periods found in these experiments, and all the evidence would appear to point to the fact that this adsorption is complete within the first second. It seems just possible that the very high value found by Meyer[15] for the surface tension of mercury in an atmosphere of hydrogen, was due to the fact that in this case very little adsorption even of gas molecules had taken place. Meyer used the vibrating jet method, and the surface of the mercury had certainly been formed for less than one second when the surface tension was recorded. Unfortunately, however, it is not known whether the same method has been employed by any other experimenter for measuring the surface tension of mercury, and the high value observed in this case (554 dynes per cm.) requires confirmation.

In order to explain his observed results, Popesco made the further assumption that an orientation of the surface-atoms occurred, this effect becoming complete at the end of 24 hours or so at ordinary pressures; a more rapid change being prevented by impacts of the gas molecules in their continual bombardment of the mercury surface. Once again, however, the fact that the atoms remain only 1/100th of a second in the surface renders such a theory untenable, and once again independent evidence points to its improbability. For, in order that orientation might occur at all and yet take place so slowly, there would be required an extremely delicate balance between the forces tending to orientate the atom and the impulses of the gas molecules which tend to prevent this. But if the orienting forces which act upon the atom are so delicately balanced as to allow complete orientation to occur only at the end of several hours, then it would be expected that an extremely slight variation of the periods between impacts of the gas molecules against a surface atom would bring about an altogether disproportionate change in the rate at which orientation occurs, by allowing the mercury atom a slightly different period in which to orient itself. Thus it might be expected that equilibrium would be reached far more rapidly in a heavy gas such as carbon dioxide or oxygen than in the case of hydrogen, where the time between impacts is so much shorter. In practice the reverse is, of course, found to be the case, and the surface tension of mercury in an atmosphere of hydrogen approaches the equilibrium value far more rapidly than in the case of any other gas observed.

That the forces which tend to orient the atom (if such is indeed the cause of the fall of surface tension) are by no means insignificant is shown by the large difference recorded between initial and final values, namely, 100 dynes per cm. All theoretical considerations from the standpoint of classical mechanical theory would appear to point to the probability of an extremely rapid orientation of a free atom, in view of its extremely small moment of inertia. The moment of inertia of molecules—such as the molecule of nitrogen—can be shown from measurements of band spectra to be of the order of 10^{-39} gm. cm.^{2}, and the value for even the comparatively heavy mercury atom would certainly not approach this order. A simple calculation will serve to show that each atom of the mercury surface must give up an energy of the order of 10^{-13} erg in order to account for the change of surface tension; which energy would thus be sufficient to cause the atom to orientate itself in a time extremely small compared even to the time which elapses between the impact of two successive gas molecules. There would thus appear to be no reason why orientation should not occur, if it is to do so at all, between the impact of two successive gas molecules. There is still the evidence of the Stern-Gerlach experiment upon the magnetic deflection of atoms, which puts in evidence the extreme rapidity with which orientation can occur, while in the gaseous state at any rate. Finally, there is certainly no evidence available of

(15) Meyer, Wied. Ann., 66, 3, 1898, p. 523.

any such lag in orientation as Popesco postulates, from the experiments upon fatty acid films upon a water surface, and the forces involved in this case are certainly smaller than those involved in the changes of surface-tension of mercury.

It appears certain, therefore, that the entire explanation given by Popesco must be abandoned and a new theory sought to explain the phenomena he describes.

Now, an examination of the experimental method employed by Popesco, and by Burdon and Oliphant, reveals the fact that these experimenters were unable to introduce gases into their apparatus without a preliminary evacuation. Nor did the construction of their apparatus allow in either case of a "baking out" in vacuo, in order to drive off the adsorbed and absorbed gases from the walls of the apparatus. These gases, as is well known, are extremely difficult to remove by any other method than by a preliminary heating at low pressures, and appreciable amounts will still be present after a vacuum has been maintained for many hours at ordinary temperatures. Water-vapour certainly forms a very large percentage of the total volume of the gases emitted.(16)

It would seem to follow that a certain amount of water-vapour must necessarily have been present in the gaseous form, even after evacuation. Consequently, no matter what precautions were taken to ensure that only perfectly dry gases were admitted to the apparatus (in neither case, unfortunately, are the precautions for drying the gas described), the gas upon entering must necessarily take up a certain proportion of the water-vapour. Now, there can be little doubt that this water-vapour is adsorbed far more strongly than are the various gases. (The interfacial tension between mercury and water is about 427 dynes per cm., while Popesco's results appear to point to a surface tension against the various gases of more than 500 dynes per cm. It has already been shown that the low value finally recorded cannot be due to a mere adsorption of gas molecules, since equilibrium is reached far too slowly.) If the possibility is admitted that very slight traces of moisture are thus present in the apparatus, either because of the giving up of water-vapour from the walls of the vessel or from the fact the gases entering the vessel are not perfectly dry, then it is possible to obtain a fairly complete explanation of the whole of the phenomena of surface-tension changes of mercury measured by the "big drop" method.

That the surface-tension of metals may be affected by the presence of these gases and vapours from the walls of the apparatus is clear from the experiments of Hogness,(17) who found that they caused an appreciable lowering of surface-tension, especially above 400°C. This is noteworthy, however, since the same experimenter found no appreciable change in surface-tension whether the experiments were performed in gas at atmospheric pressure or in vacuo, if the apparatus was baked out first at low pressures. This, of course, would appear to support the theory put forward that practically the whole variation is due to the effect of traces of water-vapour. Its importance is not emphasised, however, for two reasons. In the first place, the amounts of adsorbed and absorbed gases given off in Hogness's experiments at 400°C would be several hundred times larger than those which might be expected in the experiments of Popesco or Burdon and Oliphant. In the second place, it should be pointed out that the method of measuring surface-tension used by Hogness resembles very much the drop-weight method, which has failed in the hands of some observers to reveal differences of surface-tension in gases and in vacuo without any special precautions of baking out of the apparatus such as Hogness found necessary, *vide* Harkins and Ewing,(18)

(16) Sherwood, Journ., Am. Chem. Soc., xl., 2, 1918, p. 1645.

(17) Hogness, Jour. Am. Chem. Soc., xliii., 2, p. 1621, 1921.

(18) Harkins and Ewing, Jour. Am. Chem. Soc., xlii., 2, 1920, p. 2539.

Harkins and Grafton,[19] Burdon and Oliphant *(loc. cit.)*. Not much stress is, therefore, laid upon this observation.

Since the adsorption of the water molecules at the mercury surface involves a larger decrease of the free energy of the system than when gas molecules are adsorbed there, the adsorption of water molecules must proceed progressively at the expense of the adsorption of the gas molecules, so that the final values of the surface-tension measured by the big drop method will be those for a mercury surface almost completely covered with an adsorbed film of water molecules. Consequently, the final value of the surface-tension in all gases should approximate to the same figure independently of the gas. Moreover, all experimental evidence would appear to point to the fact that phenomena of surface-tension and interfacial-tension are governed almost entirely by the layer of molecules on either side of the boundary surface. It is to be expected, then, that the final value of the surface-tension in these various gases should also be approximately the same as the value of the interfacial tension at a mercury-water interface. The value of the latter, found by Gouy, is 427 dynes per cm., while Popesco gives the final values for the surface-tension at the end of 24 hours in the various gases:—

Air	..	..	..	..	418	dynes per cm.	
O_2	..	..	..	..	417	,, ,, ,,	
N_2	..	..	..	..	419	,, ,, ,,	
H_2	..	..	..	..	419	,, ,, ,,	
CO_2	..	..	..	..	420	,, ,, ,,	
SO_2	..	..	..	..	337	,, ,, ,,	
NH_3	..	..	..	..	390	,, ,, ,,	

Disregarding the case of the last two gases, where it is extremely probable that chemical action occurs at the mercury surface, the agreement between the other gases quoted is sufficiently striking. It is difficult to see how the surface-tension could be lowered to exactly the same extent by an adsorption of such widely different gases as hydrogen, nitrogen, oxygen, and carbon dioxide, which vary over a wide range in both their probable affinity for a mercury surface and also in the masses of their molecules. Both of these factors should markedly affect the final value of the surface-tension if adsorption of the gas were the cause of the phenomenon. Moreover, the final value for the various gases does, as expected, approximate to that of the interface mercury-water.

Now, the actual amount of water-vapour which must be present in an apparatus in order to bring about this adsorption of a monomolecular film of water on the mercury surface is very slight indeed. It has been shown that the life of a mercury atom in the surface is very short, and of the order of 1/100th of a second. Moreover, there is considerable evidence of the strong adsorption of gases at many metal surfaces *(vide*, for example, Langmuir's experiments upon the adsorption of gases at the surface of hot filaments). Consequently there seems every reason to suppose that the "time of stay" of an adsorbed water molecule at a mercury surface is at least largely governed by the time which the mercury atom to which it is attached itself remains in the liquid. In order that a large fraction of the surface should be covered with an adsorbed film of water molecules at any instant, it would then only be necessary that a large number of impacts of water molecules should occur per sq. cm. of the surface compared with the number of mercury atoms which leave the same area. Taking into account, then, the fact that a water molecule will travel with a velocity about three times that of the mercury atom, it is only necessary that the vapour-pressure of water in the apparatus should be about 33 times that of the mercury vapour in order that 99%

(19) Harkins and Grafton, Jour. Am. Chem. Soc., xlii., 2, p. 2534, 1920.

of the mercury surface should be covered with adsorbed molecules at any instant. Now, it is possible that the amount of water vapour present is of this order (·03 mm.) in both the experiments of Popesco, and in those of Burdon and Oliphant, in which case the surface-tension of a drop of mercury formed in vacuo would attain, within a fraction of a second, an equilibrium value which approximates to the interfacial tension of water.

The behaviour of the drop in the presence of a gas will not be quite so simple. Measurements of the vapour pressure of mercury in the presence of air by Morley[20] agree fairly well with those of Hill,[21] whose measurements were performed by a vacuum method. It appears reasonable to assume that the number of atoms which leave one sq. cm. of the surface in one second is the same in the presence of a gas as in vacuo. So that, even in the presence of a gas, this number of atoms must be returned to a mercury surface in equilibrium with its vapour. The gas above the mercury surface may be regarded as composed of two portions:—

(a) a surface layer of thickness a few times the mean free path of a mercury atom in the gas; and

(b) the bulk of gas which lies beyond.

It is clear that the rate at which the bulk of the gas can pass atoms of mercury to the surface will be comparatively small, and determined entirely by the rate at which atoms can diffuse through the surface layers of gas. On the other hand, much of the surface layer can give up atoms at the surface at a rate which depends simply upon the velocity of the individual atoms. It is clear, then, that in any given interval of time the number of atoms which reach the mercury surface, having diffused from the bulk of the gas, will be smaller than the number which come from the few surface layers in a ratio of the order of that of the time taken for an atom to diffuse through the surface layers divided by the time the atoms would take to traverse the same distance, if no impacts with gas molecules occurred. Since equilibrium is supposed to have been attained throughout, however, the number of atoms which proceed from the mercury surface only as far as the edge of the surface layer will be greater than that which reaches the bulk of the gas in the same ratio. Thus, of the atoms which leave the mercury surface, by far the greater number are returned to it after comparatively few collisions with gas molecules. Therefore, although the actual time of stay of the mercury atom in the surface may be only about 1/100th of a second, yet the time which is spent at, or near, the surface before the atom finally escapes into the bulk of the gas may be quite large. In a similar manner, the time which a water molecule may be held in the neighbourhood of the surface may be correspondingly lengthened. Consequently, if a mercury surface is formed in a gas at ordinary pressures, the molecules of water vapour which are adsorbed at the surface may be expected to remain at, or near, the surface for quite appreciable periods of time. On the other hand, water molecules will only slowly diffuse down to the mercury surface, so that the lowering of surface-tension will take place only very slowly, and the time taken to attain equilibrium of surface tension will depend largely upon the rate of diffusion of the water molecules through the gas. Thus, at lower pressures, equilibrium is attained much more rapidly, as is actually found by Popesco, while in vacuo it is attained almost instantaneously. Moreover, equilibrium appears to be more rapidly attained in hydrogen than in the case of the heavier gases.

There is independent evidence of the extremely small amount of some substances required in the vapour form to give a monomolecular adsorbed film. Thus

(20) Morley, Phil. Mag., 6th Ser., vol. vii., p. 662, 1904.

(21) Hill, Phys. Rev., 2nd Ser., xx., p. 259, 1922.

Micheli[22] has found that a closely packed layer of octane was formed upon a mercury surface if the vapour pressure of the former substance was as small as 5 mm. This is, of course, about 100 times larger than the pressures of water vapour which can be expected in Popesco's experiments, but on the other hand, it is the more striking as the experiments were performed at atmospheric pressure, and by the drop-weight method of measuring surface-tension, so that the surface of the mercury was exposed to the air and vapour for only a comparatively short time.

Now, if the above explanation of the changes of surface-tension observed by the big drop method is the correct one, then the values obtained by different observers may vary owing to the different precautions taken for drying the gases admitted to the apparatus, and also to differences in construction of the apparatus itself. Thus the area of the glass surface and the type of glass exposed to the gas in the apparatus may alter the water vapour content, and hence affect the values of the surface-tension obtained. Thus Burdon and Oliphant give a value for the surface-tension against dry air of about 495 dynes per cm., while Popesco's results appear to point to considerably higher values. Moreover, it might be expected that after many experiments with the same apparatus, a fatigue effect might be observable owing to the fact that the glassware no longer gave up adsorbed water vapour as readily as previously. Thus the observed value of the surface-tension at any given time after the drop was formed should appear slightly higher than when experiments were first performed with the apparatus. Now, unfortunately, Popesco makes no reference to any attempt made to repeat earlier readings after the apparatus had been much used. However, there were some measurements of the surface-tension in the various gases used which were made after the remainder of these readings had been finished. These were the measurements of the surface-tension five seconds after the formation of the drop. In the curves shown in Popesco's paper the anomalous values obtained at five seconds time after formation of the drop are completely obliterated, owing to the small time scale there employed in drawing the graphs. It is clear that the curves for each of the gases except oxygen, and possibly hydrogen, are accurately represented by straight lines from $t = 10$ secs to $t = 300$, while the decrease of surface-tension with time in these two gases certainly holds from $t = 60$ seconds onward, t being the time which elapses between the formation of the drop and the taking of the reading. It is possible, therefore, to regard the high values obtained for $t = 5$ secs. as in error relative to the other values, owing to the decreased water vapour content of the gases when 5 secs. values were recorded. Burdon and Oliphant's curve appears to support this view. On the other hand, the values obtained by Popesco for the surface-tension of the drop at $t = 10$ secs. in the two gases oxygen and hydrogen rather point to the fact that the sudden bend in the curves about $t = 10$ may be a real one in all cases. If this is the case the big drop method appears to point toward values of the surface-tension of mercury in all gases almost as high as the value found in hydrogen by Meyer *(loc. cit.)*, using the vibrating jet method. It is curious, however, that Meyer's own values do not even approach this value of 554 dynes per cm. in the presence of gases other than hydrogen.

If these curves really represent the actual manner of decrease with time, then the most likely explanation would appear to follow by assuming that either the mercury surface was still not quite steady at $t = 5$ secs., so that adsorption of gas molecules had not reached an equilibrium value, or, alternately, that quantities of gas were still in slight motion within the apparatus. A very rapid adsorption of water vapour will, no doubt, occur for a very short period of time after the formation of the mercury drop, owing to the presence of water molecules in the

(22) Micheli, Phil. Mag., 7th Ser., vol. iii., p. 895.

few layers close to the mercury where the actual velocities of the molecules will be effective in carrying them to the surface rather than a diffusion rate. It is, of course, unlikely that these few layers could contribute sufficient water molecules to the adsorbed film to lead to the large fall of surface-tension which apparently occurs, but if the gas is itself in motion within the apparatus quite an appreciable volume of it might then pass sufficiently close to the mercury surface to give the effect indicated. It is doubtful, however, what viewpoint should be adopted regarding these high values which Popesco records. In the case of oxygen, one of the gases in which the effect is most marked, several phenomena appear to point to something more than a mere physical adsorption (*vide* Burdon and Oliphant, *loc. cit.*, p. 211).

In the experiments described in this paper upon the spreading of various liquids on a mercury surface, the pressure of water-vapour within the apparatus is possibly of the order of 1 mm., so that, whereas Popesco found that the full fall of surface-tension took 24 hours to occur in his experiments, it is usually found that, owing to the far more rapid adsorption of water molecules in the present experiments, drops of water or acid will not spread readily after periods of a few minutes.

The idea that an adsorption of water-vapour at the mercury surface might prove to be the explanation of many of the observed phenomena of the surface-tension of this liquid has been advanced earlier by Iredale, who, however, found it difficult to conceive of an adsorbed layer upon a mercury surface which could be stable at such low pressures as 10^{-3} mm. Yet, even at glass surfaces, it appears by no means certain that all the adsorbed gases are given off merely by such an exhaustion, unless continued for extremely long periods, and there is much evidence to show that metals can adsorb gases or vapours far more strongly than can glass. Moreover, in order to obtain an appreciable adsorbed film it is merely necessary, as has been shown, to postulate that the time of stay of the adsorbed molecule should be of the order of 10^{-2} seconds, provided that pressure of water-vapour is of the order of 10^{-3}, or even 10^{-4} mm.

It is quite likely that the rate of evaporation of the adsorbed film from the mercury surface should be slightly greater in a vacuum. If this is the case, it might give an explanation of the fact that the vacuum value (436 dynes per cm.) is appreciably higher than the final value in the various gases (419 dynes per cm.). The different final values apparently obtained by preparing the mercury surface in vacuo and then admitting air at various pressures, may possibly have rise also in a decreased rate of evaporation as the pressure is increased.

It is not proposed to examine in detail here the "drop-weight" method of measuring the surface-tension of mercury, nor to make a detailed analysis of the results obtained by that method. It may be pointed out, however, that many of the results obtained by the best experimenters appear to agree fairly well with those obtained by the "big drop" method, except that the values are in every case about 50 dynes per cm. too low, which fact would appear to point to a wrong correction factor having been applied. Thus most experimenters obtain a value by the former method which approximates more or less closely to that of Harkins and Grafton of 465 dynes per cm. in air, and the values for the interfacial tension are usually about 75 dynes lower. The measurement over which the agreement of the various workers breaks down completely is that of the value of the surface-tension in vacuo. Now, in their attempt to measure this, Harkins and Ewing used a mercury condensation pump (a high-speed type) and the *vacuum was maintained by keeping the pump running* while measurements were being taken. Now, if the speed of the pump is sufficient, this fact may well have reduced any water-vapour which remained in the apparatus to a negligible quantity by pumping it off as quickly as it left the walls of the apparatus, so that only an inappreciable

amount of water-vapour condensed upon the drops as they formed at the tip of the dropping pipette. It seems just possible that the difference of experimental procedure in either continuing the pumping during the period of drop formation or in shutting off the pump, may lie at the root of the widely differing values obtained by different observers for the surface-tension in vacuo.

In a further paper,(23) Iredale definitely concluded that the changes of surface-tension recorded by the "big drop" method could not be explained as due to the adsorption of water-vapour. However, since it appears that his results in no way contradict the theory here put forward, an attempted explanation seems worth while.

Once again Iredale has not taken the precaution of baking out his apparatus, and consequently, although he estimates the vacuum as 10^{-5} mm. or lower, it is extremely unlikely that a sufficient vacuum can be maintained to prevent an adsorption of water-vapour sufficient to affect the surface-tension of the drop, *except while the pump is running.* Consequently, although his values for a drop formed in vacuo are considerably higher than those given by Popesco, he yet finds that the surface-tension falls after 24 hours to a value which approaches that of the latter. Moreover, each successive drop of mercury, as it is condensed upon the glass plate, will serve to give the latter a partial baking out. On the other hand, with its successive heatings as each drop condenses, this plate will form the source of by far the greater portion of any water-vapour which is given off within the apparatus. Consequently, it is to be expected that successive drops will each be prepared in a vacuum which contains less and less water-vapour, and there will thus be recorded a series of drops of increasing surface-tension. This phenomenon is recorded by Iredale, who, however, believes it to be due to the gradual removal of some contamination upon the plate. If the latter were the correct explanation, however, corresponding changes should take place for drops formed in gases, and neither Popesco nor Burdon and Oliphant make any mention of such variations.

On the other hand, the temperature of 200 to 250°C, or thereabouts, at which the mercury condenses, will certainly not be sufficient to give the plate an efficient bake out even after numbers of drops have been formed upon it, in view of the renewed heating it receives each time another drop is prepared for measurement.

Consequently, with the vapour given off from the plate and walls, the vapour-pressure will again rise steadily within the apparatus if this is left for 24 hours, until a value of the surface tension is reached for which the surface is practically covered with water molecules; *i.e.*, the same surface-tension will be reached as for a drop in contact with excess of water-vapour. Iredale gives only one set of figures, and they indicate that this is exactly what does occur. Drop 11 *(vide loc cit.*, p. 609) falls after 24 hours to 446 dynes cm. Admission of water-vapour causes the surface tension to fall in the case of another drop (p. 610) to 449 dynes cm. The difference in the two final values is thus only 3 dynes cm, and within the margin even of experimental error. There seems no reason to conclude, therefore, from Iredale's results, as he does, that an adsorption of water-vapour is not the cause of the changing values of surface-tension.

Variation with Concentration.

Variation of the Spreading Pressure with the Concentration of the Drops of Acid and Salt Solutions Applied.

Measurements have been performed with a number of substances with a view to determining the manner in which the spreading pressure exerted varies with the change of concentration of the solution. From the data thus obtained the curves shown in fig. 8 have been drawn. In most cases it will be noted that the

(23) Iredale, Phil. Mag., vol. xlix., p. 603, 1925.

pressures have been plotted against activities and not against the actual concentrations.[24] The spreading pressure for aqueous solutions of most of the substances examined appear to decrease linearly with the logarithm of the activity or concentration. The notable exception to this rule would appear to be the case of acetic acid, where a totally different type of curve has been obtained. Unfortunately, in the absence of figures for the activity of acetic acid in aqueous solution the spreading pressure was necessarily plotted against concentration, but it is doubtful whether the change of ordinate from log. concentration to log. activity would affect materially the form of the curve, although slight changes in the slope of the various portions of it would no doubt occur. The temptation would be to regard this curve for acetic acid as incorrectly determined, and its

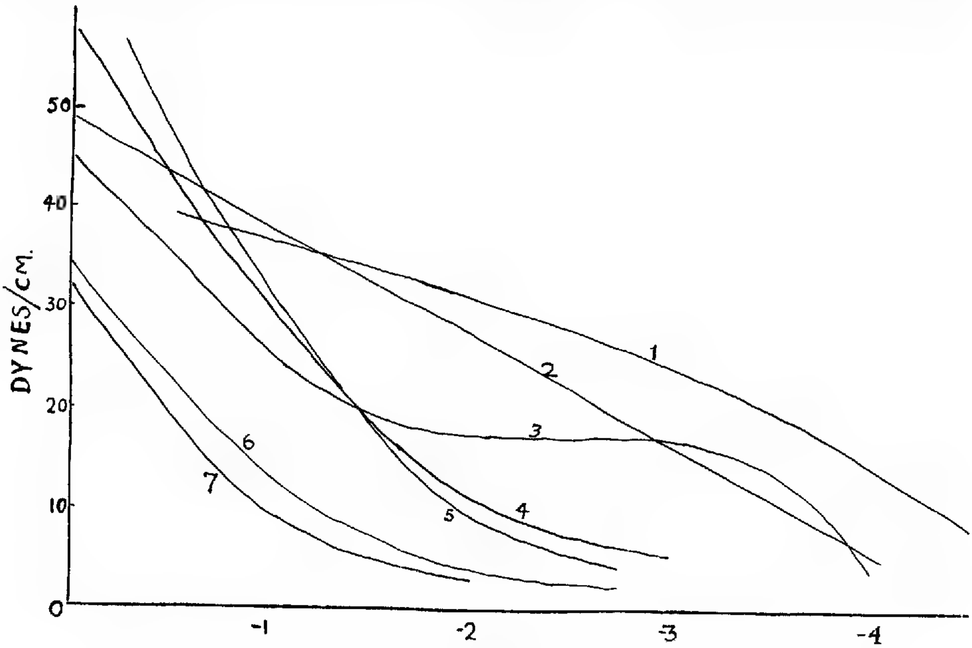

Fig. 8.

Variation of Spreading Pressure with Concentration or Activity.
1, Sulphuric Acid; 2, Hydrochloric Acid; 3, Acetic Acid; 4, Sodium Bromide;
5, Potassium Bromide; 6, Sodium Chloride; 7, Potassium Chloride.
Curves 1 and 3 plotted using logarithm of concentrations to base 10). Other curves using logarithm of activities.

departure from the simple linear form as being due simply to experimental error, were it not for the fact that this very curve has been several times confirmed upon a number of occasions, and that it is perhaps the best determined of any of the curves given. There is also the fact that hydrobromic acid appears to take up a somewhat similar form, and the few readings taken with nitric acid seem to

(24) The data necessary to transform from concentrations to activities were obtained from the following papers:—

Livingston, Jour. Am. Chem. Soc., xlviii., 1, 1926, p. 45.
Scratchard, Jour. Am. Chem. Soc., xlvii., 1, 1925, p. 641.
Scratchard, Jour. Am. Chem. Soc., xlvii., 1, 1925, p. 648.
Harned & Douglas, Jour. Am. Chem. Soc., xlviii., 2, 1926, p. 3093.

Interpolation and extrapolation were sometimes necessary to obtain the activities at the particular concentrations required. The curves for acetic acid and sulphuric acid have been plotted against concentration, as no figures were available for the corresponding activities.

indicate that in this case also there is a like departure from the linear law. No explanation has been found as yet for the variation in these cases. The horizontal portion of the graph for acetic acid with concentrations, ranging from 1/100th to 1/1,000th molar, has been put to practical advantage in the selection of a standard solution for taking check readings. The fact that the pressure remained constant over this wide range of concentration, meant that an accurate titration of the standard solution of acetic acid was unnecessary, and this solution, once obtained, it could be used over long periods of time without fear of error due to change of concentration.

A more complete discussion of these pressure-activity curves is of interest. Let

p denote the spreading pressure.
σHg denote the surface-tension of mercury.
σH_2O denote the surface-tension of water.
σS denote the surface-tension of an aqueous solution of a given acid or salt
$Hg\sigma H_2O$ denote the interfacial tension mercury–water.
$Hg\sigma S$ denote the interfacial tension mercury–solution.

Now, it is immediately clear that the spreading pressure of a drop of solution is a measure of the differences:—

$$\sigma Hg - (\sigma S + Hg\sigma S).$$
$$i.e., \; p = \sigma Hg - \sigma S - Hg\sigma S.$$

But σS is approximately equal to σH_2O within the limits of one or two dynes per cm., so that:—

$$p = \sigma Hg - \sigma H_2O - Hg\sigma S \text{ approximately.}$$

Further, it is clear from the slow spread of a drop of distilled water upon a mercury surface that:—

$$\sigma Hg = \sigma H_2O + Hg\sigma H_2O \text{ approximately.}$$
$$\text{Consequently } p = Hg\sigma H_2O - Hg\sigma S.$$

If, now, S_1 and S_2 are two concentrations of a given solution, and p_1 and p_2 the corresponding spreading pressures, then:—

$$p_1 - p_2 = dp = Hg\sigma S_2 - Hg\sigma S_1.$$

That is, the difference of spreading pressure at the two concentrations is approximately equal to the difference of the two interfacial tensions.

Now Gibbs' Adsorption Equation states that

$$\Gamma = -\frac{1}{RT}\frac{d\sigma}{d(\log_e a)}$$

where Γ is the adsorption in gm. mols. per sq. cm. of surface.
R is the constant of the perfect gas $= 8{\cdot}32 \times 10^7$ ergs per gm. mol.
T is the absolute temperature.
a is the thermodynamic activity.

This equation, then, can be applied to the results and curves given above, provided $-dp$ is written in place of $d\sigma$

$$\therefore \; \Gamma = \frac{1}{RT}\frac{dp}{d(\log_e a)} = \frac{1}{2{\cdot}3RT} \cdot \frac{dp}{d(\log_{10} a)}$$

Hence the total number of molecules, n, adsorbed per sq. cm. of surface will be given by

$$n = \frac{N}{2{\cdot}3RT} \cdot \frac{dp}{d(\log_{10} a)}$$

where N is the Avogadro number and is equal to $6 \cdot 06 \times 10_{23}$. Therefore the area occupied by each of these molecules at the surface is

$$A = \frac{2 \cdot 3RT}{N} \cdot \frac{d(\log_{10} a)}{dp}$$

$$= \frac{2 \cdot 3 \times 8 \cdot 32 \times 10^7 \times 290}{6 \cdot 06 \times 10^{23}} \cdot \frac{d(\log_{10} a)}{dp}$$

Now, over the upper portion of each of the pressure-activity curves,
$p = k \log a$, where k is a constant. Hence over these portions of the curves the adsorption must likewise be constant, independently of the actual values of the concentration; and the area occupied by an adsorbed molecule must also remain the same. These areas have been worked out for each of the substances plotted in fig. 8, and are given in column 2 of Table III. It will immediately be evident that these areas approach the well-known order of molecular size. In view of the fact, then, that the same amount of adsorption takes place for any one substance over quite a wide range of concentration, it might be inferred that this stable adsorbed layer represents some type of monomolecular film, the molecules of which are already in some kind of tightly packed state. It is difficult to explain this constant area which each molecule takes up on the mercury surface unless some such closely packed layer is postulated, which can prevent the adsorption of further molecules as the concentration is increased.

TABLE III.

Substance.	Area from Gibbs' Adsorption Equation. Sq. Cm. $\times 10^{-16}$.	Area of Cross Section of larger Ion, Sq. Cm. $\times 10^{-16}$.	Sum of Areas of Cross Section of 2 Ions. Sq. Cm. $\times 10^{-16}$.
KCl	40·2	11·83	18·59
NaCl	55·5	11·83	15·87
NaBr	33·3	14·74	18·78
KBr	26·2	14·74	21·50
HCl	84·8	11·83	—
HBr	49·2	14·74	—
H_2SO_4	147·7	—	—
$HC_2H_3O_2$	47·0	25·1	—

In the first place, if the lowering of interfacial tension is caused by the adsorption of neutral molecules of the substance in solution, then it is possible that an orientation of these molecules occurs, so that all the positive or all the negative ions are attached to the mercury surface, while those of opposite sign are attached to this layer. The molecules would thus stand on end much after the fashion of the fatty acid molecules adsorbed at a water surface. If this is the case, however, the area occupied by an adsorbed molecule upon the mercury surface will be completely determined by the area of cross section of the larger ion or by the "head" of the molecule. Now, these latter areas are comparatively well known, either from crystal analysis by X-rays, or in the case of acetic acid from measurements of the fatty acid films upon water. Bragg[25] has accepted the values given by Wasastjerna[26] and [27] as being the most probable for a

(25) Bragg, Phil. Mag., Ser. 7, 2, 1926, p. 262.

(26) Wasastjerna, Soc. Scient. Fenn. Comm. Phys. Math., xxxviii., p. 1, 1923.

(27) Wasastjerna, Soc. Scient. Fenn. Comm. Phys. Math., p. 26, 1926.

number of ionic radii, and it is from these that the areas of cross section given in column 3 of Table III. have been calculated. In the case of acetic acid the value given is that obtained by Adam. It is at once evident that in each case the area of cross section is considerably less than that actually occupied by the molecule upon the mercury surface.

While such an orientation of neutral molecules adsorbed at the mercury surface may be regarded as possible, experiments have been performed which render it rather improbable. For example, the work of Patrick and Bachman[28] appears to show that there is a differential adsorption of the ions themselves. Moreover, the fact that Burdon found it possible to aid or retard spreading of solutions electrically, as well as the whole mass of experimental work upon electro-capillary phenomena, would seem to point to the fact that the ions can be separately adsorbed. Whether this hypothesis of adsorption of the individual ion is accepted, or that of neutral molecules horizontally oriented, the area occupied per molecule upon the mercury surface will be slightly larger than before, but will still be smaller than the areas actually occupied, as calculated from Gibbs' Equation Column 4 gives the approximate areas of the molecules oriented horizontally when calculated from Wasastjerna's figures. These values are still far too low, and an explanation of the discrepancy must apparently be sought from some other source.

Unfortunately, there does not seem to be any exact parallel among other phenomena to this adsorption at the mercury surface. On the one hand, the unsaturated valency forces which come into play in the adsorption of neutral molecules of fatty acids at a water surface must be so very much weaker than the electric forces between the ions adsorbed at the surface of mercury that the analogy between the two cases is probably a superficial rather than a real one. And on the other hand, the examination of crystal structures will also probably avail little, since the forces within the single adsorbed layer must be altogether different from those pertaining to the interior of a crystal where the electric forces are determined, not by one, but by a number of similar layers. It is difficult, therefore, to form an adequate picture of the order and arrangement of these molecules or ions when they are attached to the mercury surface. One fact remains clear, however. The adsorbed film is apparently not a closely packed film of the same type as might be imagined if a single layer of a crystal were sliced off and placed upon the mercury surface. The effective diameters of the atoms which form the film are considerably larger than those of the same atoms when they form part of a crystal lattice. Measurements of atomic diameters by means of collision phenomena (viscosity, etc.) likewise give values which are considerably larger than those given by the X-ray analysis of crystalline salts. It seems that the adsorbed film on the mercury surface should be regarded as a "liquid" film in which the adsorbed atoms are not packed in any definite pattern, and in which the diameters of the individual atoms or ions are to be compared with the diameters of similar atoms in the liquid or gaseous states, rather than with the diameters of the ions in a crystalline salt.

In conclusion, thanks are due to Mr. R. S. Burdon and Mr. M. L. Oliphant for much advice and assistance, both with regard to the theoretical and the practical difficulties in connection with the carrying out of the work recorded in this paper.

(28) Patrick and Bachman, Jour. Phys. Chem., 30, p. 134, 1926.

NEW AUSTRALIAN LEPIDOPTERA.

By A. Jefferis Turner, M.D., F.E.S.

[Read September 12, 1929.]

Fam. BOARMIADAE.

Niceteria, n. gen.

νικητηριος. victorious.

I propose this generic name for *Satraparchis? macrocosma* Low, in place of *Aprosita* (Proc. Linn. Soc. N.S. Wales, 1917, p. 387), pre-occupied by myself in the Anthelidae (Trans. Roy. Soc. S. Austr., 1914, p. 456).

Fam. NOCTUIDAE.

Canthylidia zorophanes, n. sp.

ζωροφανης, of simple appearance.

♂, 32 mm. Head and thorax whitish-brown. Palpi brown-whitish. Antennae whitish-brown; ciliations in male very short. Abdomen and legs whitish. Forewings elongate-triangular, rather narrow, costa nearly straight, apex rounded, termen very obliquely rounded; uniform whitish-brown without markings; cilia whitish-brown. Hindwings with termen rounded; whitish; cilia whitish.

West Australia: Rottnest Island, in November; one specimen received from Mr. W. H. Matthews.

Sideridis palleuca, n. sp.

παλλευκος, all white.

♀, 40 mm. Head and palpi whitish. Antennae grey, becoming whitish towards base. Thorax, abdomen, and legs whitish. Forewings elongate, costa straight, apex round-pointed, termen obliquely rounded; whitish; a few scattered blackish scales towards dorsum before middle; a minute blackish discal dot beyond middle; a series of blackish dots on veins forming a curved line from $\frac{4}{5}$ costa very obliquely outwards, thence becoming transverse, and finally curved inwards to $\frac{2}{3}$ dorsum; a slight greyish suffusion towards termen; a minute blackish dot at apex; cilia whitish with a fine interrupted median grey line. Hindwings with termen slightly sinuate; whitish; cilia white. Underside whitish.

Distinct by its uniform whitish colour without any ochreous or brownish tinge.

West Australia: Rottnest Island, in November; one specimen received from Mr. W. H. Matthews.

Catoblemma mesotaenia, n. sp.

μεσοταινιος, with median band.

♀, 22 mm. Head grey with some ferruginous suffusion. Palpi $2\frac{1}{4}$; ferruginous-grey. Antennae pale grey. Thorax and tegulae pale grey; patagia ferruginous. Abdomen and legs grey. Forewings triangular, costa nearly straight, slightly sinuate towards apex, apex pointed, termen strongly rounded, slightly sinuate beneath apex, slightly oblique; pale grey, a broad median purplish-grey band, undefined anteriorly, posteriorly defined by a fine fuscous slightly dentate line, outwardly curved from $\frac{2}{3}$ costa to $\frac{3}{4}$ dorsum; a subterminal series of fine fuscous dots; terminal area beyond this dark grey; cilia dark grey. Hindwings with termen rounded; pale grey; cilia grey.

Queensland: Brisbane, in March; Victoria: Birchip, in November.

Two specimens; in that from Birchip one forewing has an areole, very small but of normal development, with 10 arising from it separately.

Eublemma phaeocosma, n. sp.

φαιοκοσμος, with dark ornament.

♀, 25 mm. Head grey. Palpi $2\frac{1}{4}$; grey. Antennae grey. Thorax and tegulae pale grey; patagia grey. Abdomen and legs pale grey. Forewings triangular, costa straight, apex quadrangular, termen rounded, wavy, scarcely oblique; pale grey with slight fuscous irroration towards base; costal edge whitish-ochreous with a dark fuscous dot near base, and interrupted by short dark fuscous outwardly oblique streaks at $\frac{1}{4}$ and shortly before and after middle, between the last and apex interrupted by three grey dots; from near the third costal streak proceeds a line at first transverse and slightly dentate, then curved inwards, and again outwards to dorsum before tornus. this line, a blotch of patchy irroration preceding it, and a transverse oblong median discal spot are ferruginous-fuscous; a subterminal series of blackish dots, that beneath costa larger and sometimes connected by a fine streak with costa before apex; cilia grey with a paler basal line. Hindwings with termen rounded; as forewings but without discal spot, postmedian line, and blotch; subcostal terminal dot small, subtornal dot larger.

North Queensland: Dunk Island, in May; one specimen.

Oruza lithochroma, n. sp.

λιθοχρωμος, stone-coloured.

♂, 25 mm. Head brown. Palpi long, second joint exceeding vertex; brown-whitish irrorated with fuscous. Antennae brownish-grey; in male slightly dentate, shortly ciliated. Thorax and tegulae whitish-grey; patagia brown. Abdomen and legs pale grey. Forewings triangular, costa straight, apex pointed, termen nearly straight, slightly sinuate, not oblique; whitish-grey with some dark fuscous irroration; basal $\frac{2}{3}$ of costal edge brownish; a small 8-shaped discal spot outlined in fuscous; a wavy transverse fuscous line from $\frac{2}{3}$ costa to $\frac{3}{5}$ dorsum; three dark fuscous dots on costa beyond this; a narrow brownish-grey terminal suffusion; an interrupted fuscous terminal line; cilia brownish-grey, apices whitish. Hindwings with termen only slightly rounded; grey with slight fuscous irroration; paler towards base; an interrupted fuscous terminal line; cilia grey.

North Queensland: Stannary Hills, near Herberton; one specimen received from Dr. Thos. Bancroft.

Nanaguna polypoecila, n. sp.

πολυποικιλος, variegated.

♂, 22 mm. Head whitish irrorated with fuscous. Palpi $1\frac{1}{2}$; whitish irrorated with fuscous. Antennae fuscous, towards base grey. Thorax whitish irrorated with fuscous; posterior crest fuscous. Abdomen grey; basal crest fuscous. Legs whitish with some fuscous irroration. Forewings triangular, costa strongly arched, apex quadrangular, termen slightly rounded, slightly oblique; whitish irrorated with fuscous; a moderate basal patch, strongly indented above dorsum, and containing a blackish subcostal spot; a fuscous line from $\frac{1}{3}$ costa to $\frac{2}{5}$ dorsum, strongly angled outwards beneath costa, inwards in middle, and again outwards; a second fuscous line from $\frac{2}{3}$ costa, strongly outwardly oblique, forming a rather acute curve in disc above middle, thence sinuate to $\frac{2}{3}$ dorsum; the median band included between these lines is mostly fuscous, but with irregular areas of whitish suffusion along posterior edges towards costa and dorsum; terminal area fuscous, towards tornus ferruginous-fuscous with suffused whitish patches towards costa and beneath middle; a fine interrupted dark fuscous terminal line; cilia fuscous above middle, below middle whitish, but interrupted by fuscous above tornus.

Hindwings with termen rounded; grey-whitish; veins and terminal area grey; cilia grey.

North Queensland: Cairns, in May; one specimen.

Calathusa cyrtosticha, n. sp.

κυρτοστιχος, with curved line.

♀, 28 mm. Head and thorax pale grey. Palpi 2; whitish with some fuscous irroration. Antennae pale grey. Abdomen and legs grey. Forewings elongate, costa strongly arched, apex quadrangular, termen rounded, not oblique; pale grey; a darker median band occupying middle third of wing; edged anteriorly by an outwardly curved fuscous line from $\frac{1}{4}$ costa to $\frac{1}{3}$ dorsum; posteriorly by a fuscous line from $\frac{2}{3}$ costa to $\frac{2}{3}$ dorsum, very strongly outwardly curved; within median band orbicular and reniform are outlined first in whitish, then in fuscous; a slender, finely dentate, whitish, subterminal line; dark fuscous submarginal and terminal lines; cilia grey, apices paler. Hindwings broad, termen sinuate; grey becoming paler towards base; cilia whitish. Underside of forewings pale fuscous; of hindwings whitish with fuscous terminal band.

Best distinguished by the strongly curved postmedian line.

Queensland: Brisbane; one specimen.

Calathusa polyplecta, n. sp.

πολυπλεκτος, many-striped.

♀, 32 mm. Head brown-whitish. Palpi $2\frac{1}{2}$; whitish, with some fuscous irroration. Antennae fuscous. Thorax pale grey, anteriorly brownish-tinged. Abdomen brownish; terminal segments fuscous. Legs fuscous annulated with brown-whitish; posterior pair mostly brown-whitish. Forewings elongate, posteriorly broadly dilated, costa moderately arched, apex quadrangular, termen rounded, scarcely oblique; pale grey partly tinged with brownish; some fuscous irroration on costa near base; a fuscous line from $\frac{1}{4}$ costa to $\frac{1}{3}$ dorsum, wavy; a postmedian blackish line from costa just beyond middle to $\frac{2}{3}$ dorsum, outwardly curved in upper half, straight and inwardly oblique in lower half; between these are orbicular and reniform, pale and outlined with fuscous; postmedian line followed by a brownish and this by a whitish shade; fuscous submarginal and terminal lines; a long blackish streak on fold from $\frac{1}{4}$ nearly to termen; similar streaks between veins from shortly before and cutting through postmedian line to termen; cilia grey mixed with whitish. Underside of forewings fuscous; of hindwings whitish with lunate discal mark and terminal band fuscous.

Queensland: Cleveland, near Brisbane, in September; one specimen received from Mr. P. Franzen.

Clytophylla, n. gen.

κλυτοφυλλος, like a glorious leaf.

Tongue strongly developed. Face smooth, porrect. Palpi in female short, slender, ascending, appressed to face; in male extremely short, not reaching face; second joint shortly rough-haired; terminal joint minute. Antennae of male simple. Thorax and abdomen without crests. Posterior tibiae smooth. Forewings with 2 from $\frac{3}{5}$, 6 from below upper angle of cell, 7 and 8 stalked, 9, 10, 11 all separate and free, no areole. Hindwings with 3, 4, and 5 connate, cell open, discocellulars not being developed, 7 separating from 6 at about $\frac{1}{3}$, 12 closely approximated to cell throughout, and to basal portion of 7, but not connected. Retinaculum of male broadly bar-shaped.

This genus belongs to the same group as *Earias* Hb., *Hylophila* Hb., and *Halias* Treit., but is peculiar in having 10 separate and free from the cell. Incidentally the structure of the hindwings shows that the Hylophilidae of Meyrick

(Revised Handbook of British Lepidoptera, p. 48) cannot be maintained as a separate family.

Clytophylla artia, n. sp.

ἄρτιος, perfect.

♂, 42 mm.; ♀, 45 mm. Head green on crown, fillet and face white. Palpi in male $\frac{1}{2}$, in female 1; whitish mixed with brown. Antennae brown, towards base whitish; in male simple, minutely ciliated. Thorax bright green. Abdomen white. Legs pale green; anterior tibiae, inner aspect of anterior femora, and of middle tibiae and femora, fuscous brown. Forewing sub-oblong, costa strongly arched, apex acute, termen sinuate, dentate, slightly oblique; bright green with long slender transverse paler strigulae in dorsal half; a blackish dot edged with orange-brown in mid-disc at $\frac{1}{4}$; a median white discal dot, ringed first with fuscous-brown, then with orange-brown; costal edge white; cilia grey, bases orange-brown, with a median interrupted white line. Hindwings with termen rounded; white; cilia white, on costa pale green.

This magnificent species fully deserves its name.

Queensland: Bunya Mountains (3,000 feet), in January; two freshly-emerged specimens. I have also seen an example taken by Mr. W. B. Barnard, at Toowoomba.

Subfam. OPHIDERINAE [Noctuinae Hmps.].

Crioa hyperdasys, n. sp.

ὑπερδασυς, very hairy.

♂, 52 mm.; ♀, 46 mm. Head fuscous mixed with whitish. Palpi $2\frac{1}{2}$; fuscous mixed with whitish. Antennae fuscous; in male minutely ciliated with longer (1) paired bristles on each segment. Thorax with a long expansile anterior crest; fuscous mixed with whitish. Abdomen pale ochreous-fuscous on dorsum with 2 to 5 small fuscous median crests on basal segments; in male densely hairy beneath, the hairs directed outwards from a median parting. Legs fuscous; tibiae and tarsi annulated with whitish-brown; in male middle and posterior pairs very densely clothed with long whitish-brown hairs throughout. Forewings elongate-triangular, costa moderately and evenly arched, apex rounded; termen slightly rounded, crenulate, scarcely oblique, about $\frac{2}{3}$ length of dorsum; underside in male, except costal and terminal margins, forming an orange-brown androconial area, edged towards costa by three ridges of raised hairs; brownish-fuscous suffused and irrorated with brown-whitish; lines fuscous; a short oblique streak from costa preceding antemedian line; antemedian line from $\frac{1}{4}$ costa very obliquely outwards and slightly dentate to fold, there forming an acute outward tooth, a smaller outward tooth above dorsum, ending on $\frac{1}{3}$ dorsum; an indistinct dentate line from mid-costa, sometimes connected with antemedian by a longitudinal streak above middle of disc; postmedian from about $\frac{2}{3}$ costa, indistinct at origin, outwardly oblique to below middle, then looped inwards but only slightly upwards, to beneath middle of disc, there forming a narrow loop, thence outwardly oblique and sharply dentate to $\frac{3}{4}$ dorsum; reniform not defined; a pale dentate subterminal line; a terminal series of whitish-ochreous dots connected by fuscous streaks with subterminal; cilia brownish-fuscous. Hindwings with termen rounded, crenulate; brownish-fuscous; paler towards base; cilia brownish-fuscous.

Very similar to *C. acronyctoides,* but the postmedian line is differently formed, and the male may be immediately distinguished by the underside of the forewings.

North Queensland: Thursday Island, two males, one female; also one example from Cairns in Coll. Lyell.

Crioa hypsichaetes, n. sp.

ὑψιχαιτης, with long hairs.

♂, 46 mm. Head fuscous mixed with brownish. Palpi $2\frac{1}{2}$; fuscous; anterior surface of second joint, median ring and apex of terminal joint, pale brownish. Thorax with an expansile anterior crest; fuscous mixed with brownish. Abdomen fuscous; darker median dorsal crests on first five segments, that on fourth larger; underside clothed with whitish-brown hairs without defined median parting. Legs fuscous; tarsi annulated with ochreous-whitish; posterior tibiae and tarsi in male densely hairy on dorsum, and with a pencil of hairs from base longer than tibiae itself. Forewings elongate-triangular, costa straight to $\frac{3}{4}$, thence arched, apex rounded, termen slightly rounded, crenulate, oblique, nearly as long as dorsum; dark brownish-fuscous suffusedly paler towards dorsum and termen; markings very obscure; a small circular dark-ringed median spot representing orbicular; a short dentate pale transverse line from $\frac{3}{4}$ costa halfway across disc; several obscure pale costal dots; a series of short blackish interneural streaks running into pale terminal dots; cilia fuscous, bases paler. Hindwings with termen slightly rounded, crenulate; fuscous; cilia grey-whitish.

North Queensland: Dunk Island, in May; one specimen.

Crioa emmelopis, n. sp.

ἐμμελωπις, harmonious.

♂, ♀, 34-36 mm. Head brown. Palpi $1\frac{1}{2}$; fuscous brown, anterior edge and apex paler. Antennae fuscous; in male very shortly ciliated ($\frac{1}{3}$). Thorax brown; tegulae grey-whitish. Abdomen brownish. Legs pale brown; tarsi dark fuscous annulated with brown-whitish. Forewings elongate-triangular, costa gently arched, apex rounded, termen slightly rounded, slightly oblique, crenulate; basal half brown, sharply limited by an oblique wavy line from midcosta to $\frac{3}{4}$ dorsum; beyond this is a dense white irroration, except on a narrow terminal band; a fine wavy blackish oblique line, edged on both sides with whitish, not reaching fold, sometimes preceded by a darker shade; a brown costal spot just beyond middle, and three similar dots between this and apex; a fine dentate white subterminal line; a blackish spot on outer edge of this below middle; a fuscous terminal line; cilia brown, slenderly barred with white. Hindwings with termen rounded, subcrenulate; pale-brownish or fuscous; a suffused whitish postmedian shade and a similar subterminal line; cilia brown, apices white. Underside of hindwings with a discal spot and markings more distinct.

North Queensland: Evelyn Scrub, near Herberton, in February; Queensland: Nambour, in September. Two specimens.

Crioa niphobleta, n. sp.

νιφοβλητος, snow-beaten.

♀, 28-34 mm. Head white, a small tuft of dark fuscous scales just inside base of antennae. Palpi long, second joint reaching vertex, terminal joint $\frac{2}{3}$ second; white, external surface of second joint, a narrow basal and broad subapical ring on terminal joint, dark fuscous. Antennae grey, towards base with blackish rings. Thorax dark fuscous; tegulae, apex and posterior surface of crest white. Abdomen whitish-ochreous; crests blackish, large on first two segments, minute on fourth. Legs white, irrorated and tarsi ringed, with blackish; posterior pair whitish. Forewings triangular, costa straight, slightly arched towards base and apex, apex rounded-rectangular, termen slightly rounded, slightly oblique, crenulate; white with fuscous and blackish markings, near termen fuscous-whitish; a fuscous spot on base of costa edged by a blackish line; a fuscous sub-basal fascia edged externally by a blackish dentate line; a sub-

quadrate fuscous spot on costa at $\frac{2}{5}$, connected by a line with a fuscous suffusion in disc, and this with $\frac{2}{5}$ dorsum; reniform slenderly outlined, transverse, suboval, slightly constricted in middle; postmedian line dentate, blackish, from $\frac{2}{3}$ costa to near dorsum, then bent upwards and inwards touching lower edge of reniform, there looped and ending on $\frac{2}{3}$ dorsum, the first bend is connected with dorsum by a short line; a dark fuscous fascia with two posterior teeth succeeds this, except near costa, where there is a white interval; a blackish terminal line; cilia white with blackish bars. Hindwings with termen rounded, subcrenulate; fuscous-whitish with a broad fuscous terminal band; cilia whitish.

Queensland: Toowoomba, in October, December, and February; three specimens received from Mr. W. B. Barnard.

Alophosoma, n. gen.

ἀλοφοσωμος, with uncrested abdomen.

Face with strong obtusely-rounded prominence covered by scales. Tongue strongly developed. Palpi long, ascending, exceeding vertex; second joint thickened with scales, rough anteriorly; terminal joint long, smooth-scaled, obtuse. Antennae of male minutely ciliated, with longer (1) paired bristles on each segment. Thorax with a long expansile anterior crest, and two small posterior crests. Abdomen without dorsal crests; undersurface in male covered with long hairs directed outwards from a median parting. Posterior tibiae with basal, median, and terminal tufts of hair on dorsum. Neuration normal.

Allied closely to *Crioa*, but the abdomen has no dorsal crests.

Alophosoma syngenes, n. sp.

συγγενης, of common origin.

♂, 40 mm. Head brown. Palpi fuscous, anterior edge pale brownish. Antennae fuscous. Thorax fuscous; patagia and anterior crest brown. Abdomen fuscous. Legs fuscous; tarsi annulated with whitish-ochreous; posterior pair whitish-ochreous. Forewings elongate-triangular, costa gently and evenly arched, apex rounded-rectangular, termen rounded, crenulate, slightly oblique; grey with patchy brown suffusion; a fine, blackish, wavy antemedian line from $\frac{1}{3}$ costa to dorsum before middle; reniform large, grey, clearly defined, succeeded by an area of grey-whitish suffusion; postmedian fine, blackish, from $\frac{2}{3}$ costa, at first transverse and twice dentate, below middle looped strongly upwards and inwards, touching lower extremity of reniform, where it forms a bilobed loop and becomes outwardly oblique, ending on $\frac{3}{4}$ dorsum; an indistinct pale dentate subterminal line; a dark fuscous terminal line; cilia fuscous, bases pale brownish. Hindwings with termen rounded, crenulate; fuscous becoming grey-whitish towards base; cilia whitish with some indistinct fuscous bars.

North Queensland: Kuranda, near Cairns, in June; one specimen.

Crypsiprora oostigma, n. sp.

ὠοστιγμος, with oval bands.

♀, 30 mm. Head brown-whitish with a few fuscous scales. Palpi brown-whitish irrorated with fuscous. Antennae brown-whitish slenderly ringed with fuscous brown. Thorax pale brownish mixed with dark fuscous. Abdomen whitish irrorated with fuscous; crests fuscous. Legs fuscous; tarsi annulated with whitish. Forewings elongate-triangular, costa gently and evenly arched, apex rounded, termen rounded, slightly oblique; pale brownish irrorated with fuscous; lines dark fuscous, slender; a sub-basal line curved outwards beneath costa; an antemedian line from $\frac{1}{4}$ costa, dentate, strongly outwardly oblique to fold, there acutely angled inwards, ending on $\frac{1}{4}$ dorsum; orbicular large, oval,

oblique, brown-whitish, slenderly outlined with dark fuscous; reniform larger, oval, transverse, brown-whitish, outlined with dark fuscous, more strongly anteriorly; postmedian very slender, dentate from beneath $\frac{3}{4}$ costa, obsolete towards dorsum; an interrupted subterminal line edged posteriorly with brown-whitish; several dark fuscous costal dots between and beyond lines; terminal area paler and crossed by short dark fuscous longitudinal streaks; a fine dark fuscous terminal line; cilia whitish barred with dark fuscous. Hindwings with termen rounded; fuscous, paler towards base; a darker discal dot and curved postmedian line; cilia as forewings but whiter. Underside of hindwings with markings more distinct.

West Australia: Donnybrook; one specimen received from Mr. L. J. Newman.

Hypoprora tortuosa, n. sp.

tortuosus, winding.

♂, 28 mm. Head and thorax fuscous. Palpi 2; grey-whitish, external surface except apex fuscous. Antennae grey; in male slightly dentate, shortly ciliated ($\frac{1}{2}$), with a pair of longer bristles ($1\frac{1}{2}$) on each segment. Abdomen grey; crests fuscous. Legs fuscous; tarsi annulated with whitish. Forewings triangular, costa moderately and evenly arched, apex rounded-rectangular, termen slightly rounded, moderately oblique, crenulate; fuscous, markings blackish; an outwardly bent sub-basal line not reaching dorsum; antemedian strongly dentate, from $\frac{1}{4}$ costa to $\frac{1}{3}$ dorsum, reniform large, medially constricted, faintly outlined; postmedian from beneath $\frac{3}{4}$ costa, bent outwards and twice obtusely dentate, thence bent inwards and upwards along lower edge of reniform, forming an approximately circular loop, thence dentate to $\frac{2}{3}$ dorsum; a pale, slender, dentate subterminal line; a blackish terminal line; cilia fuscous. Hindwings with termen gently rounded, wavy; fuscous-whitish, rather darker towards termen, a slightly darker discal mark and two curved postmedian lines; a dark fuscous terminal line; cilia grey-whitish. Underside of hindwings distinctly marked, but with only one postmedian line.

Very similar to *H. lophosoma* Turn., but the lines are differently formed, and the male of that species has pectinate antennae.

Queensland: Charleville, in September; one specimen.

Prorocopis acroleuca, n. sp.

ἀκρολευκος, white at the apex.

♂, 30 mm. Head brownish; face whitish. Palpi 3, second joint reaching vertex, terminal joint nearly as long as second; whitish with some fuscous irroration. Antennae grey; in male minutely ciliated with a pair of short bristles on each segment. Thorax brownish-fuscous with lateral white lines. Abdomen fuscous, apices of segments brown. Legs whitish; anterior and middle tibiae and tarsi ringed with fuscous. Forewings elongate-triangular, costa slightly bisinuate, apex rectangular, termen slightly rounded, slightly oblique, crenulate; white, irrorated, and terminal area wholly suffused, with grey; lines slender, blackish; a sub-basal line strongly bent outwards, forming a subrectangular projection; a line from $\frac{1}{6}$ costa to $\frac{1}{3}$ dorsum, nearly straight but slightly angled outwards beneath costa and inwards in middle; a slender grey strongly angled line from $\frac{1}{3}$ costa to mid-dorsum; reniform large, grey, medially constricted posteriorly; postmedian line from midcosta, angled inwards beneath costa, thence longitudinal touching upper edge of reniform, prolonged subcostally to near $\frac{3}{4}$, there bent, transverse, and slightly wavy and outwardly curved, below middle bent upwards and inwards to touch lower edge of reniform, there forming a narrow loop, and continued wavy to $\frac{2}{3}$ dorsum; this is closely followed by two slender dark grey lines; a dentate

fuscous subterminal line, which bisects a white subapical costal spot; a terminal line; cilia grey, bases and apices whitish. Hindwings with termen slightly rounded, crenulate; grey-whitish; a broad fuscous terminal band narrowing towards tornus; cilia whitish, bases fuscous.

Queensland: Gayndale; one specimen received from Dr. Hamilton Kenny. I have seen a second taken on the Bunya Mountains at 3,000 feet.

Prorocopis latens, n. sp.

latens, hidden.

♀, 25-30 mm. Head and thorax grey with whitish irroration. Palpi $2\frac{1}{2}$, terminal joint $\frac{1}{2}$ second; whitish-grey. Antennae grey. Abdomen ferruginous-brown, towards apex fuscous. Legs grey; posterior pair whitish. Forewings elongate-triangular, costa gently arched, apex pointed, termen slightly rounded, rather strongly oblique; grey; antemedian line indicated by an obscure fuscous oblique streak from $\frac{1}{4}$ dorsum to fold; second line by a short fuscous transverse streak from $\frac{2}{3}$ dorsum edged posteriorly by whitish or brownish; a grey-whitish narrow terminal band, interrupted above middle, shortly edged with fuscous near dorsum; cilia grey. Hindwings with termen sinuate; pale fuscous; cilia pale fuscous, apices whitish.

Very obscure, without the characteristic markings but with the structural characters of the genus.

Queensland: Charleville, in September and December; two specimens.

Acanthoprora streblomita, n. sp.

στρεβλομιτος, with winding thread.

♂, ♀, 26-29 mm. Head and thorax fuscous with whitish irroration. Palpi $1\frac{1}{2}$; fuscous with whitish irroration. Antennae grey, towards base fuscous; in male shortly ciliated (1). Abdomen grey-whitish, some irroration and basal crest grey. Legs fuscous irrorated with whitish; posterior pair except tarsi mostly whitish; tarsi ringed with whitish. Forewings elongate-triangular, costa nearly straight, gently arched towards apex, apex round-pointed, termen slightly bowed, slightly oblique; fuscous irrorated with whitish, appearing grey, main lines blackish, other lines fuscous and more or less distinct; a transverse sub basal line from costa not reaching dorsum; two more or less distinct fuscous transverse lines succeed this; a nearly straight line from $\frac{1}{4}$ costa to $\frac{1}{4}$ dorsum; a dentate transverse median fuscous line, sometimes indistinct; reniform slenderly outlined, large, transverse, indented posteriorly; postmedian line from $\frac{3}{4}$ costa, straight and only slightly outwardly oblique to below middle, there bent inwards and upwards to lower edge of reniform, then forming an approximately circular loop, and continued wavy to $\frac{2}{3}$ dorsum; an indistinct fuscous transverse line succeeds this; an irregularly dentate fuscous subterminal line, a fuscous terminal line; cilia fuscous, apices whitish. Hindwings with termen rounded; whitish; a moderate fuscous terminal band narrowing at tornus; cilia whitish.

Queensland: Charleville in December; Cunnamulla; two specimens.

Euprora tanyphylla, n. sp.

τανυφυλλος, with long wings.

♀, 32-42 mm. Head pale brown; face sometimes fuscous brown. Palpi $1\frac{1}{4}$; pale grey or pale brown. Antennae grey, towards base brown-whitish. Thorax and tegulae pale grey; patagia and an anterior spot pale brown. Abdomen pale grey. Legs pale grey. Forewings elongate-oval, costa strongly arched, apex rounded-rectangular, termen slightly rounded, oblique; whitish-grey, sometimes

suffused with brown, sometimes with scattered blackish dots or short streaks on veins; a very obscure darker line from $\frac{1}{6}$ costa to $\frac{1}{5}$ dorsum, curved strongly outwards beneath costa; a broadly suffused, outwardly curved, fuscous or brown median line, preceded closely by a fine blackish dentate line from costa, not reaching beyond middle of disc; reniform obsolete, but indicated by an inwardly curved lunate blackish line above middle of disc; postmedian line very slender, fuscous, wavy, from before $\frac{3}{4}$ costa to $\frac{2}{3}$ dorsum, outwardly curved; beyond this a parallel series of short blackish streaks on veins; three blackish costal dots on posterior third; a whitish suffusion succeeds median line and is prolonged beneath costa to or towards termen; a slender interrupted whitish subterminal line; a blackish terminal line; cilia whitish-grey or brownish-grey. Hindwings broader, termen slightly sinuate; grey or brownish-grey, sometimes broadly whitish towards base; cilia grey, apices whitish, towards tornus wholly whitish.

Evidently variable in colouration.

North Queensland: Kuranda, near Cairns; Evelyn Scrub, near Herberton. Two specimens received from Mr. F. P. Dodd.

Saroptila platysara, n. sp.

πλατυσαρος, with broad brushes.

♂, 30 mm. Head fuscous. Palpi $3\frac{1}{2}$; second joint exceeding vertex, terminal joint $\frac{1}{3}$, with a small subapical posterior tuft; fuscous. Antennae grey; in male moderately ciliated (1), with a pair of long bristles (3) on each segment. Thorax fuscous. Abdomen grey. Legs fuscous; posterior pair mostly whitish-ochreous. Forewings triangular, costa nearly straight, apex rounded, termen rather strongly rounded, scarcely oblique; a tuft of long hairs on underside from upper margin of cell near its end, directed downwards and outwards, partly covering a pale androconial area; pale ochreous-fuscous; lines slender, dentate, fuscous; first from $\frac{1}{4}$ costa to $\frac{1}{3}$ dorsum; second from $\frac{3}{4}$ costa to $\frac{2}{3}$ dorsum, outwards from costa, but soon nearly straight and finely dentate to dorsum; a more obscure, only slightly dentate, subterminal line; a whitish dot in disc above middle at $\frac{1}{4}$, and another in middle at $\frac{1}{3}$; cilia concolorous. Hindwings broadly oval, elongate anteroposteriorly; on underside with three oblique ridges of moderately long hairs, extending from near middle to near termen, directed inwards and backwards; pale ochreous-fuscous; a rather large subcostal area bare of scales; cilia concolorous.

Very similar to *S. milichias* Turn., but the brushes on underside of hindwings are an easy distinction.

Queensland: Montville (1,500 feet), near Nambour, in March; two specimens.

Fam. TORTRICIDAE.

BARNARDIELLA SCIAPHILA Turn.

Queensland: Nambour District; four specimens bred in November from larvae feeding on banana fruit (J. A. W.).

Epichorista gonodesma, n. sp.

γωνοδεσμος, with angled band.

♀, 14 mm. Head and thorax reddish-brown. Palpi 3; second joint with long spreading hairs beneath; reddish-brown. Antennae grey. Abdomen fuscous; tuft ochreous-whitish. Legs brownish. Forewings suboblong, not dilated, costa gently arched, apex rounded-rectangular, termen straight, scarcely oblique; brown-whitish with some grey suffusion in terminal area; markings reddish-brown; a

small basal patch; a rather narrow median fascia from costa before middle to mid-dorsum, angled acutely outwards in middle, on costa suffused with fuscous; preceding this are four fine outwardly-angled transverse lines; four whitish dots surrounded and bisected by reddish-brown and fuscous on terminal half of costa; a grey-centred tornal spot; an apical spot; an oblique line from beneath $\frac{3}{4}$ costa to termen below middle; terminal edge brown-whitish; cilia brown-whitish with fuscous dots on apex and below middle of termen, bases reddish-brown. Hindwings with termen sinuate; dark grey; cilia pale grey with dark basal and apical lines.

Queensland: National Park (3,000 feet), in March; one specimen.

Fam. GLYPHIPTERYGIDAE.

PHYCODES.

Phycodes Gn., Noct., ii., p. 389; Meyr., Gen. Insect., Glyphipt., p. 18.

Head and thorax smooth. Antennae short, $\frac{1}{2}$ or less, in male simple. Palpi very short, curved, ascending, laterally compressed, smooth. Middle and posterior tibiae smooth except opposite origin of spurs. Forewings with all veins present and separate, 2 from long before angle of cell ($\frac{3}{4}$). Hindwings with 3 and 4 connate or stalked, 5 parallel or slightly approximated at base, 6 and 7 separate, nearly parallel.

Type, *P. radiata* Ochs., from India.

A genus of about a dozen recorded species from India and Africa. It has not been previously recorded from Australia.

PHYCODES ADJECTELLA.

Nigilica adjectella Wlk., Cat. Brit. Mus., xxviii., p. 512.

♂, ♀, 12-16 mm. Head and thorax grey with metallic lustre; face brassy. Palpi minute; fuscous. Antennae very short, in male $\frac{1}{3}$, in female $\frac{1}{4}$; fuscous; in male somewhat thickened, simple. Abdomen fuscous. Legs fuscous; apices of middle and posterior tibiae and tarsal annulations white. Forewings somewhat dilated, costa moderately arched, apex rounded, termen straight, not oblique, rounded beneath; fuscous densely irrorated with brassy-whitish, scales mostly arranged in transverse rows; base lustrous-grey; a narrow black fascia broadly edged with brilliant brassy lines from $\frac{1}{3}$ costa to $\frac{2}{5}$ dorsum; a similar fascia from before $\frac{2}{3}$ costa to $\frac{4}{5}$ dorsum, giving off a brassy black-edged line from its centre to costa before apex; a brassy tornal dot, above which is a black spot, and above this a brassy streak, edged above with black, to midtermen; termen and cilia black with coppery lustre. Hindwings fuscous-brown towards base thinly-scaled; a small pencil of white hairs from near base of dorsum in both sexes; cilia fuscous.

North Queensland: Townsville, in October, December, and January. Received from Mr. F. H. Taylor, who found it abundant, and attached to the Indian Tamarind *(Tamarindus indica)*, with which it has doubtless been imported. Also from China, Ceylon, India, and Africa.

Amphimelas, n. gen.

ἀμφιμελας, black all round.

Head smooth. Tongue present. Palpi long, recurved, sickle-shaped; second joint smooth, exceeding base of antennae; terminal joint as long as second, smooth, slender, laterally compressed, acute. Antennae of female about $\frac{1}{2}$, filiform; basal joint rather stout. Thorax not crested. Middle and posterior tibiae with median and terminal whorls of hairs, otherwise smooth. Forewings with 11 veins, 2 from $\frac{3}{4}$, 3 and 4 connate from angle, 7 and 8 coincident, 9 approximated, 11 from middle.

Hindwings over 1, subquadrate, cilia 1/6; 3 and 4 stalked, 5 parallel, approximated, 6 and 7 connate.

Amphimelas argopasta, n. sp.

ἀργοπαστος, sprinkled with white.

♀, 16-17 mm. Head blackish; face white. Palpi blackish; second joint except base and apex white. Antennae blackish. Thorax blackish, some irroration and a posterior dot white. Abdomen blackish, apices of segments white, more broadly so beneath. Legs blackish; tibial whorls of hairs and tarsal annulations white. Forewings suboblong, not dilated, costa gently arched, apex rounded-rectangular, termen straight, scarcely oblique; blackish with white irroration, which forms indistinct oblique bands, first from costa near base to dorsum near middle, second from costa before middle to dorsum beyond middle, third from 3/4 costa to tornus; a terminal series of white dots; cilia fuscous with slight purple lustre. Hindwings and cilia blackish.

New South Wales: Mittagong, in November; two specimens received from Mr. G. M. Goldfinch, who has the type.

Fam. HYPONOMEUTIDAE.

Atteva niphocosma Turn.

Larvae whitish, each segment with a broad blackish ring of coalesced spots except in cephalic and caudal segments; in these the rings are replaced by two large trilobate spots touching on dorsum; head brown. Feeding gregariously in an open web on a jungle shrub on Palm Islands, North Queensland. Pupae grey mottled with blackish, fixed by tail in web, more or less erect.

Pauridioneura, n. gen.

I propose this name for *Pauroneura* Turn. (Proc. Roy. Soc. Tas., 1926, p. 158), used previously by me in the Gelechiadae.

Fam. HEPIALIDAE.

Porina aedesima, n. sp.

αἰδεσιμος, venerable.

♂, 55 mm. Head, palpi, and thorax fuscous. Antennae whitish-ochreous; in male shortly bipectinate (1), pectinations densely but shortly ciliated. Abdomen pale fuscous, at base slightly rufous-tinged. Legs pale fuscous. Forewings elongate, suboval, costa sinuate, apex rounded, termen very obliquely rounded; pale fuscous densely irrorated with fine whitish-ochreous hairlike scales; a dark fuscous costal streak; an outwardly oblique, narrow, oblong, whitish, discal mark before middle slenderly outlined with fuscous; three oblique lines consisting of fuscous spots, often whitish in centre, variably developed; first from midcosta outwardly curved around discal mark, thence straight to 2/5 dorsum; second from 3/4 costa to 3/5 dorsum, nearly straight; third from 7/8 costa to tornus, nearly straight; sometimes an imperfectly developed similar sub-basal line; cilia fuscous with a few whitish-ochreous scales. Hindwings with termen strongly rounded; pale fuscous tinged with rufous towards base, or wholly pale rufous; cilia fuscous.

North Queensland: Eungella (2,500 feet), behind Mackay, in October; two specimens.

Trictena argyrosticha, n. sp.

ἀργυροστιχος, silver-striped.

♂, 106-120 mm. Head, thorax, abdomen, and legs pale brown. Palpi about 1; brown. Antennae whitish-ochreous; in male tripectinate, lateral pectinations 4,

median ventral pectinations rather shorter. Forewings elongate, suboval, costa straight to $\frac{2}{3}$, thence arched, apex tolerably pointed, termen slightly rounded, strongly oblique, longer than dorsum, with which it forms a continuous curve; brown, towards costa narrowly and suffusedly pale brown, towards dorsum very broadly and definedly pale brown; more or less marked with fine, parallel, curved, scroll-like, darker and paler lines, forming near termen concentric oval rings, which have occasionally whitish centres; an irregular-edged, rather broad, median, longitudinal, shining-white streak, from near base to beyond middle, with irregular teeth above and beneath; sometimes a few small white spots in disc beyond this; a similar but untoothed oblique streak from just beneath apex to midway between end of median streak and anal angle; cilia brown-whitish. Hindwings broadly oval, termen strongly rounded; pale brown, sometimes with pale fuscous suffusion posteriorly.

Apart from the different colour the forewings are narrow, with longer termen, and more pointed apex, and the palpi rather shorter than in *T. labyrinthica* Don.

Queensland: Montville, near Nambour, in March; Toowoomba in April; six specimens.

NOTES ON, AND DESCRIPTIONS OF, CHALCID WASPS IN THE SOUTH AUSTRALIAN MUSEUM.

Concluding Paper.[1]

By A. A. Girault, Assistant Government Entomologist, Queensland.
(Communicated by Arthur M. Lea, F.E.S.)

[Read September 12, 1929.]

The following data and descriptions comprise a final report upon a collection of the Hymenopterous family Chalcididae loaned to me by the Director, South Australian Museum. The types are in the named museum, cotypes in the Queensland Museum at Brisbane, but a few are otherwise disposed of, as noted in the text.

Subfamily EUPELMINAE.

Genus Eupelmus Dalman.

1. Eupelmus antipoda Ashmead.

A female specimen, Launceston, Tasmania (F. M. Littler), December 17, 1916.

The basal $\frac{1}{4}$ of ovipositor is aeneous, rest yellow. The species differs from *E. splendidus* in bearing a longer ovipositor (half abdomen's length) and in the different colour of this organ. The metallic colour is deep and the tibial tips in leg 3 sharply contrast. Postmarginal somewhat exceeds the stigmal. Runs to *splendidus* in my revised table of the genus *Eupelmus* (Australian).

2. Eupelmus worcesteri Girault.

A female, Murray Island, Torres Straits (A. M. Lea).

Tibia 2 has the distal two-thirds red-brown. Scutellum finely long-lineolated.

3. Eupelmus splendidus Girault.

A female with No. 2. Differs from *E. antipoda:* Frons a bit wider, more opaque, without rows of pin-punctures (eyes, mesopleurum bare in both), ocelli in smaller triangle, shorter ovipositor, stigmal vein more curved and equal postmarginal.

4. Eupelmus redini Girault **argentilineus**, n. var.

As typical form but entirely purple except a linear exfoliation along the whole of tibia 2 beneath, this silvery. Lateral ocelli nearly twice wider apart than either is distant from median. Tarsi more or less brown beneath; middle tibial spur brown; scutum densely pilose.

A female, March 23, 1916, Launceston, Tasmania.

5. Eupelmus extraordinarius Girault.

Fore wing with two eye-spots. Aeneous; knees, tibial tips, tarsi except 1 of 3 and most of tibia 2 except proximad, brown; ovipositor shortly extruded, white except at base narrowly; eye-spots small, elliptical, separated by more than their length, the caudal isolated from caudal margin; postmarginal over twice the stigmal; silvery band abdomen wide; ocelli in a flat triangle, lateral closer to eye than to

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[1] The writer desires to thank all who gave aid. The first (and only other) part was printed in Records S. Austr. Museum, part, iii., 1927, pp. 309-338.

median; funicles 2-3 over twice longer than wide, exceeding pedicel, latter brown at apex. Cephalic mesopleurum pilose, a row of elongate hairs across neck of prothorax (dorsad). Antennae somewhat above eye ends. In table follows *E. giottini*.

A female, Cairns district (A. M. Lea).

6. EUPELMUS CAESAR Girault.

Runs to *E. chauceri* but differs from that species and *E. nelsonensis* by colour of the legs; in the same way from *E. shakespearei;* like *E. brutus* but femur 3 aeneous for proximal $\frac{3}{4}$; tibia 3 aeneous above for proximal $\frac{2}{3}$ except just at base. The rows of thimble punctures along the eyes down the face are very distinct, in the other species usually absent or obscure. Mesopleurum naked in all. Ovipositor here nearly half abdomen, narrowly blue at base and apex, but at latter more widely, middle half or more white. Fore tibia aeneous above and below only.

The species is also characterised by having the first four segments of the abdomen deeply notched at hind margin; and the whitish hairs of the face, lobes of scutum and prepectus conspicuous.

Four female type specimens reared from *Eublemma* species on *Ceroplastes rubens,* Custard apple, Redland Bay, February 23, 1926 (A. A. Girault and W. A. T. Summerville). Two cotype females reared from larva *Lygropia clytusalis* Walk., "Currajong Bag-shelter Moth," Darwin, North Australia, November 1, 1913 (G. F. Hill).

7. EUPELMUS MAWSONI Girault SOLIS Girault.

A female, Adelaide, by sweeping; a female, Mount Lofty, South Australia (J. G. O. Tepper). Femora entirely yellow mesad except 3, so also the tibiae.

Genus PAROODERELLA Girault.

1. **Parooderella goethei,** n. sp.

To follow *P. semiputata.* Frons the same but ocelli equidistant (lateral much closer to eye than to median).

Dull reddish, the head and antennae except scape, aeneous; hind margin pronotum, cephalic mesopleurum, hind margin of segment 2 of the abdomen, purple, tegulae black; ovipositor $\frac{1}{6}$ abdomen, white. Hind coxa purple at base above. Fore wing nearly thrice longer than wide, truncate and widest at apex, fuscous, ciliated on about basal half, venation to costa at apex, hence marginal vein punctiform. Joint 3 of the funicle equal to the pedicel, 2 longest, nearly thrice longer than wide. Pronotum with a median sulcus. Head and eyes pilose, also dorsal abdomen which has a velvety appearance. Scutum hispid.

A female, Chinchilla, Queensland, February, 1928 (A. P. Dodd).

Genus METAPELMA Westwood.

1. METAPELMA GOETHEI Girault.

The type is in the South Australian Museum, cotype in Queensland Museum.

Genus CERAMBYCOBIUS Ashmead.

1. CERAMBYCOBIUS PAX Girault.

A female specimen from Strahan, Tasmania (H. J. Carter and A. M. Lea). Tibia except ends metallic, tarsi black except joint 1.

Genus NEANASTATUS Girault.

1. NEANASTATUS DESERTENSIS Girault.

A female, Melrose, South Australia, October (A. M. Lea).

Genus EUSANDALUM Ratzeburg.

1. **Eusandalum longiannulum,** n. sp.

Head as long as wide, antennae at eye ends, the rather large, round, somewhat bulging eyes equal to cheeks, the scrobes forming a deep V-shaped cavity with thick-ridged sides which on vertex form two obtuse "horns." Funicle 2 about 7 times longer than wide, rest gradually shortening, 1 quadrate, pedicel small.

Abdomen elongate, last segment stylate and compressed, extending nearly to apex ovipositor and one-third rest of abdomen, latter twice length thorax plus head. Postmarginal vein elongate, equal marginal, over four times the stigmal. Vertex subquadrate, finely cross-lined, caudal margin concave, cephalic excavated and "horned," the ocelli nearly in a straight line on cephalic margin, lateral close to eye, rather farther from median. A tubercle between antennae. Scape extending far above vertex. Eyes bare.

As *E. compressiscapus* but fore wing with a deep wide, midlongitudinal fuscous stripe, apex to base and touching apex of the short stigmal, latter with distinct neck; funicles and postmarginal longer.

A female, Georgetown, Tasmania, November 16, 1914.

Subfamily SIGNIPHORINAE.

Genus MATRITIA Mercet.

1. **Matritia hebes,** n. sp.

As *M. thusanoides* but hyaline band of wing 1 a triangle whose base is distad and the length of the stigmal vein distad of the apex of that vein, and whose apex is lost in an hyaline area from the marginal vein, and which ends at about centre, but meets another clear area on caudal margin opposite most of submarginal vein; the distal margin of the farthest clear area is acutely concaved. Tibia 1 entirely black. Distal fringes just exceeding stigmal vein. No accessory discal bristle on wing 2.

Head and thorax smooth, a few indistinct pin-punctures. Pedicel not ½ scape. Lateral ocellus close to eye, far distant from median.

Three females from spider eggs in a leaf-nest. Tasmania.

Subfamily ENCYRTINAE.

Genus EPICHEILONEURUS Girault.

1. **Epicheiloneurus cinctiventris,** n. sp.

Abdomen with a silvery cinctus across apex segment 2 dorsad. Purple.

Head, scape save apex, leg 1, tip tibia 3, tibia 2, neck of thorax, orange; tarsi, knee 3, tegula at base, femur 2 mostly, silvery. Fore wing with a wide, deep cross stripe from bend of submarginal vein distad to a point half way to apex from apex of stigmal. Scutellum, axillae, green, with sparse hairs, former with no apical bristles. Hairless line with about 9 lines cilia proximad of it and from which proceeds a paired curved line to base, this and first few lines near base, coloured, rest pale; hairless line closed in middle of wing and also against venation.

Frons wide. Distal three funicles with several flattened bristles on apex of one side. A pair of lines of discal cilia along submarginal to base. Marginal four

times longer than wide, twice the stigmal, postmarginal shorter than stigmal. Scape clavate, distinctly compressed and dilated. Pedicel exceeding funicle 6.

A female, Mount Lofty, South Australia, in tussocks.

Genus Anagyropsis Girault.

1. Anagyropsis cicada Girault.

Both sexes, Mount Pleasant, South Australia (Loveday), February 9, 1897, from galls and lerp. Also two large females, Cradle Mountain, Tasmania (H. J. Carter and A. M. Lea).

The male is coloured like the female but the antennae are entirely lemon and curious. There are four large, equal ring-joints and a long, cylindrical, thick 3-jointed club whose joint 2 is shortest, half longer than wide, 1 and 3 each twice longer than wide. The club is densely hispid, the hairs short. The pedical and scape are short, latter much dilated but longer than wide.

In the male there is also another curious modification which I have never as yet met with in this family. The middle tarsi are black, while the spur is flattened and spindle-shaped and also black.

2. **Anagyropsis longistylus**, n. sp.

As *A. channingi* but funicles 1-2 longest, nearly twice longer than wide, exceeding the short pedicel; ovipositor two-thirds the abdomen's length, latter produced into a very narrow, elongate stylus, which nearly attains apex of ovipositor; postmarginal a bit shorter than stigmal; flagellum except basal part pedicel, yellowish. Tibia 3 immaculate.

Scape's dilation not great, distad, the scape clavate, dorsal margin serrate. Mesopleurum bare. Wing 2 with 28 lines of dense discal cilia.

3. Anagyropsis howardii Girault.

A female, attracted to light, Rockhampton, Queensland (A. M. Lea).

The frons is punctate, the ocelli nearly equidistant, lateral near eye. In the above specimen, the apical half of coxa 2 was yellow.

Genus Coccidoxenus Crawford.

1. **Coccidoxenus aeneoculex**, n. sp.

As *C. minutella* Girault but frons moderately wide (scape a bit pale beneath at apex), leg 2 yellow save coxa and a blotch above on tibia at basal $\frac{1}{4}$ (near base); scape with some distal dilation; wing ciliated to base, costal cell entirely ciliated; apex tibia 3 rather widely pale (more so ventrad); discal cilia distad of venation distinctly finer, very fine and dense. Tegulae dark save across base.

Moderately small species, the ovipositor a bit extruded. Funicles quadrate, enlarging distad, half length pedicel.

One female, Lucindale, South Australia (A. M. Lea).

Genus Epiencyrtoides Girault.

1. Epiencyrtoides quinquedentatus Girault

As *E. axillaris* but cinctus of tibia 2 short yet exceeding the short white proximad of it; coxa 1, femur 2, femur 1 (except at sides), tibia 1 at base, concolourous; jaws 4- and 5-dentate, 4 of 5-dentate minute but distinct, 5 as in the other mandible. Wings clear. Scape, club and pedicel above black. Funicles 5-6 quadrate. Postmarginal equal marginal, a bit exceeding stigmal. Four lines cilia proximad hairless line, distad of it cilia fine and uniform. Submarginal setae long bristles.

Male antennae 5-jointed, 2 ring-joints, 2 half of 1 which is somewhat wider than long; a very long, solid, hairy club, which is yellowish.

Ovipositor shortly extruded.

Reared from *Chionaspis ? eucalypti* Froggatt, on loganberry, Melbourne, Victoria, March 2, 1927 (G. F. Hill). Paratypes in South Australian and Queensland Museums.

Genus RHOPALENCYRTOIDEA Girault.

1. RHOPALENCYRTOIDEA DUBIA Girault.

A female and a dozen more in another lot, Melrose, South Australia, October (A. M. Lea).

The funicles 1-3, 4-6 are usually in two groups, the second exceeding the first but all quadrate. Sometimes 3 is equal 4 and therefore belongs to the second group. Sometimes the postmarginal vein is a bit shorter than the stigmal.

This is a variable species. I have once redescribed it from New South Wales under the name *R. cinctifemur.*

2. **Rhopalencyrtoidea austrina,** n. sp.

As *R. claripennis* but all funicle joints twice longer than wide, 1 shortest, 2 a bit longer, subequal to the pedicel; 2 of mandible longer than 1; fore wing lightly infuscated, more deeply so across from marginal and stigmal veins, latter subequal, distinctly shorter than the postmarginal vein; only 2 lines of cilia close the mouth of the hairless line at caudal margin; middle tibia purple nearly to apex; scape subrectangularly dilated. Palpi dark, 3- and 4-jointed, 4 of maxillary elongate. Second wing densely ciliate, wide, 26 lines of cilia which do not extend quite to base.

A female, Strahan, Tasmania (H. J. Carter and A. M. Lea).

Genus EPIBLATTICIDA Girault.

1. **Epiblatticida puparia,** n. sp.

Jaw 3 obtuse, not widened. Frons of moderate width.

As *E. lambi* but coxae, femora (2 only washed from base), tibia 1 at basal one-third (often), and tibia 3 more or less at basal $\frac{1}{4}$ purple; scape, apex pedicel, funicles 5-6, legs (yellow), knee 1 widely, white; funicles 1-4 dusky pale. Scape more or less dusky. Venation black, postmarginal less than half the marginal, half stigmal. Three lines of loose and coarser cilia, proximad hairless line and one line along submarginal to base.

Abdomen depressed, beehive-shaped, smaller than thorax, ovipositor extruded not quite for half length of abdomen. Sculpture very fine. Vertex, upper thorax with scattered short, black setae; a few small punctures on vertex.

Male similar but frons wider, antennae filiform, scape less dilated, dusky, pale at apex; club longest of flagellum, solid, hairy, funicle 1 twice longer than wide, longest, 6 a bit longer than wide, equal pedicel. Funicles with longish, irregularly placed, soft hairs.

Reared from a puparium, Byfield, Queensland (J. L. Froggatt), March 29, 1926. Cotypes in Queensland Museum.

Genus APHYCUS Mayr.

1. **Aphycus nigrivarius,** n. sp.

Golden, wings clear, black as follows:—A wide stripe across upper occiput, face of prothorax, nearly cephalic half scutum, pronotum laterad, axillae except laterad and a mark on scutum in front of them; a large, acute triangle on scutellum with its apex at base and the mark attaining nearly to apex of the region, where

it terminates in a cross-stripe; dorsal thorax along scutellum; propodeum except meson and lateral margins; meson upper abdomen widely (at apex entirely across). Legs with faint traces of dusky spots. Scape moderately dilated. Jaws 2-3 shallowly divided, jaw teeth small.

Funicles 1-3 equal, globular, rest enlarging, 6 quadrate, subequal pedicel. Postmarginal equal the punctate marginal; hairless line closed by several lines, discal cilia to base. Scutum with scattered, short setae.

Type a female, Brisbane (on a gum leaf), Queensland (A. R. Brimblecombe), September 30, 1926. Cotypes, a series reared by Mr. G. F. Hill from *Eriococcus coriaceus,* Hawthorn, Victoria, April 1, 1927. In the cotypes the black of scutum was less and that of scutellum scarcely produced cephalad from the cross-stripe. There are two dusky blotches on tibia 3 above, base and apex. In the male, the axillae, scutellum, all of scutum except latero-caudal corner, dark green. The flagellum is lighter, with long hairs, the club solid, long, funicles much shorter, ½ longer than wide, exceeding pedicel.

Genus CRISTATITHORAX Girault.

1. **Cristatithorax sublimus,** n. sp.

Differs from *C. novimandibularis* in having tibia 1 purple except apex, abdomen purple only widely at base above, a spot above and below middle knee purple. Cephalic ocellus twice farther from lateral than latter are from each other. Elsewise as in *C. mackayensis.*

Reared with *Coccophagus exiguiventris* at Darwin, North Australia (G. F. Hill).

Genus NEOCLADIA Perkins.

1. NEOCLADIA HOWARDI Perkins.

A male, reared in association with "*Phlyctaenodes pilosus* Pascoe," South Australia.

The club is elongate, solid, subequal to the branches which are narrower at base and above armed with stout, long spines; joint 6 of the funicle is distinctly longest, 5 quadrate, rest wider than long; club much exceeding the scape. Labial palpi 3-jointed, 2 small, 3 longest but not long, rather swollen. Marginal vein longer than wide, the postmarginal distinctly exceeding the stigmal. Fore tibia all yellow beneath.

The teeth of the mandibles were not seen in this specimen, but after mounting this is often impossible as the jaw itself must be dissected off and floated. There is a branch from each joint of the funicle.

Genus ARHOPOIDEUS Girault.

1. ARHOPOIDEUS BREVICORNIS Girault.

A female reared from wattle galls, May, 1897, South Australian Museum.

There were three distinct lines of cilia proximad of the hairless line; the postmarginal vein in this specimen was distinct, short.

2. **Arhopoideus semiargenteus,** n. sp.

Fore wing with a wide smoky band across it from costal margin distad of venation (touching base of stigmal vein and all of postmarginal) and thus characterised. Aeneous, head and thorax densely, finely punctate; tarsi, fore tibia beneath, at sides and apex, tibia 2, basal third hind tibia and the linear exfoliation of the scape at apex beneath, silvery. Joints 3-5 of the funicle a little wider than long. Second wing obtuse at apex, 20-22 lines of cilia. Pedicel subequal to joint 1 of the funicle, funicle 2 quadrate. A short postmarginal vein.

One female, North Pine River, Queensland, November 17, 1928 (H. Hacker).

The palpi in this genus are 1- and 2-jointed, and the group is thus further characterised.

Genus AENASIELLA Girault.

1. AENASIELLA ANALIS Girault.

Several females labelled: "Parasites of *Brachyscelis*, Jetulpa, 2/Neita (Mrs. Tarrant), 11.3.02. Emerged June 25, 1903."

The scutum is densely pilose. Of the 8 lines of discal cilia proximad of the hairless line, the fourth is almost on over cephalic half, so that there are two groups of 3 and 4 lines. The maxillary palpi bear a conical tooth-like projection at the base of the constricted basal part, giving the appearance of a bifid or cleft apex. This character, that of the divided ciliation back of the hairless line and the shorter ovipositor and somewhat larger abdomen distinguish the species from *Rhopalencyrtoidea dubia* which it closely resembles.

In the original description the name of this species was misspelt *amplis*.

Genus COPIDOSOMA Ratzeburg.

1. COPIDOSOMA AUSTRALIA Girault.

A female, Sydney, New South Wales (A. M. Lea).

The frons is punctate.

Genus EUCHEILONEUROPSIS Girault.

1. EUCHEILONEUROPSIS ABNORMIS (Girault).

A female, Sydney, New South Wales (A. M. Lea).

The silvery part of the middle tibia (over basal half) was not purplish beneath. Lateral ocellus near eye, very far from the median.

Genus PARAENASOMYIIA Girault.

1. **Paraenasomyiia feralis**, n. sp.

As *P. orro* but ovipositor not extended, all dark purple except knees, tarsi tibial tips; wings with a slight stain against marginal and stigmal veins; funicle 6 is nearly as long as the others (joint 1 of the club longer than wide, exceeding 1 of the funicle in width and length); 6 loose lines of discal cilia proximad of the hairless line, several lines to base cephalad and caudad; marginal vein a bit longer than wide, half the stigmal, latter somewhat shorter than the postmarginal; costal cell entirely ciliate. Dilation of scape linear and distad. Wings clearer proximad of the hairless line. Abdomen not twice longer than wide at base. Scutum pilose. Maxillary palpus with 4 elongate, 1 long, rest short; 3 of the labial palpus shorter than 1, 2 shortest. Bulla and palpi dark. Joints of the funicle slightly shorter than pedicel.

A female, Adelaide South Australia (J. G. O. Tepper).

Subfamily APHELININAE.

Genus ABLERUS Howard.

1. ABLERUS RHEA Girault.

Runs to *A. pan* in my revised table and is like *A. hyalinus*, but antennae black except apex pedicel, only the distal end of the parapside is pale, funicles shorter, 3 transverse, fringes one-third to one-half wing width; 2-3 lines coarser, dark cilia back from stigmal, discal cilia distinct, not dense, 12 lines. Caudal fringe wing 2 exceeding width. Funicle 1 equal pedicel and 2, half longer than wide. Head ivory, deep aeneous on face below antennae but pale at meson or immediately beneath them.

Type and cotype female reared from a coccid on *Callitris robusta,* Injune, Queensland, April, 1927 (J. H. Smith). The cotype, as usual, for the Queensland Museum.

Genus Coccophagus Westwood.

1. Coccophagus exiguiventris Girault.

As description of *C. pulcini* but differs as follows:—Uniformly dull honey; stripes of abdomen usually 4 (4-5), 1 and sometimes 2 widely interrupted at meson, 4 abbreviated each side; antennae of uniform colour, honey; funicle 1 exceeds 2; lateral ocelli twice closer to eye than to median; setae from marginal smaller than those from submarginal; axillae as pilose as scutum and scutellum, latter with a slender seta each side at apex; pilosity white; stigmal vein oblique, globular, its neck as long as its knob; fringes at apex short.

Abdomen smaller than thorax. Scutellum naked mesad apically.

Pedicel of male globular, flagellum filiform, distal ½ abdomen black, rest pale with two brownish marginal dashes between base and middle.

Reared from a large *Lecanium* (No. 316, W. W. Froggatt), Darwin, North Australia, September 6, 1916 (G. F. Hill). Ten male, female types and paratypes upon one card mount.

Subfamily PERILAMPINAE.

Genus Meselatus Girault.

1. Meselatus fasciatipennis Girault.

A female, Sydney, New South Wales (A. M. Lea).

In this specimen the entire head was black. The long hair of lateral scutum and so forth is from punctures. Propodeal median carina forked. Distal funicles twice wider than long. Propodeum reticulate, rough in places.

2. Meselatus subatriventris Girault.

Many specimens of both sexes from Port Jackson figs (A. J. Coates), Sydney, New South Wales.

Scutellum with an elongate seta at apex; cilia of fore wing rather dense, the wing lightly embrowned to apex from about distal one-third submarginal vein. Marginal and submarginal bristles gross. Elongate setae from dorsal hind tibia and also from femur 3 beneath and above (in the male more stout and more conspicuous, the femur much enlarged). Scattered elongate bristles on thorax.

The male antenna bears one less funicle (1 + 1 + 1 + 6 + 1), the ring-joint distinctly longer than wide, exceeding funicles, the pedicel longer than in the female.

Genus Systolomorpha Ashmead.

1. Systolomorpha thyridopterygis Ashmead.

Many specimens from galls of *Cylindrococcus casuarinae,* November, 1907, Victor Harbour, South Australia (D. H. Cushman). A female, Tarcoola (A. M. Lea).

Genus Coelocyba Ashmead.

1. Coelocyba persimilis (Girault).

A female, Lucindale, South Australia (A. M. Lea).

Vertex and frons with numerous umbilicate punctures. Lateral ocellus over twice closer to the eye than to the median. Pedicel a bit longer than wide. Hind coxa enlarged, compressed. One hind tibial spur very short. Scutum, parapside, cephalic half scutellum with many short, black setae. Band 6 of abdomen a transverse mark across meson widely. Proximal margin of the discal ciliation of fore wing wedge-shaped, acute.

Genus Coelocybelloides Girault.

1. Coelocybelloides mediolineatus Girault.

Launceston, Tasmania, No. 2010, December 7, 1915.

The stigmal vein is only half the length of the marginal. The wings are more or less embrowned. Head pin-punctate, the punctures bearing minute setae. Both palpi are 2-jointed. The amount of black on the parapside varies, and the centre of the mesopleurum is black as well as the base of the hind coxa.

2. Coelocybelloides pulchrivariegatus Girault.

Five males, two females, reared from galls on *Eucalyptus*, Tintinara, South Australia (J. G. O. Tepper). Emerged March 2, 1887.

The maxillary palpi are 4-jointed in both sexes, the labial apparently 3-jointed. Hence the species is not congeneric with *C. mediolineatus*. The segmentation of the palpi is very little known in this group, perhaps because of the difficulty in seeing them.

3. **Coelocybelloides pulchra**, n. sp.

As *C. aureus*, but base of abdomen, pleura and venter of thorax, prothorax also lemon; dorsal thoracic sutures not black, dorsal scape except at base, dorsal pedicel, green; no black on dorsal thorax except the spiracle and a spot near the base of the second wing. Apex of abdomen widely black and the curved stripe 4 is rather close to it. Venation yellow distad of the submarginal vein. Funicle 1 as wide as 2, each $\frac{1}{4}$ longer than wide and nearly as long as the pedicel. A large species with black mesoventer.

A female, Ooldea, South Australia.

4. **Coelocybelloides nigrisetae**, n. sp.

From *C. pulchra:* Thoracic sutures black, black setae along each side of the scutellum and along the parapsidal furrows; abdomen as in *C. aureus* but the cross-bands cover the entire surface from basal $\frac{1}{3}$ to distal $\frac{4}{5}$; the pubescence is black, grey in *pulchra*. Venation black except basal $\frac{1}{2}$ of the marginal vein.

Both species differ from *C. aureus* in the more widely-spaced bands of the abdomen.

A female, Ooldea, South Australia.

Genus Perilampus Latreille.

1. Perilampus tasmaniensis Girault.

A female, Tasmania (A. Simson, No. 2709).

Genus Epelatus Girault.

1. Epelatus eurytomoidea Girault.

The type locality is Melrose, South Australia, October (A. M. Lea).

The first funicle joint is nearly twice longer than wide.

Subfamily CLEONYMINAE.

Genus Episystole Girault.

1. Episystole poeta Girault.

One female, Murat Bay, South Australia.

Genus Platygerrhus Thomson.

1. **Platygerrhus incola**, n. sp.

As *P. dugandani* but fore wing with a complete loop, narrow centrally with suffused cross-stripes from each end; and dusky apex; segment 2 glabrous; stigmal vein over half the postmarginal; legs yellow for the most part except coxae;

femur 1 is somewhat more swollen than 3 and deeply excised beneath at apex (1 less than 3 in other and not excised).

Scape red-brown except apex; funicle 2 equal the long pedicel, femora mostly pale, all blotched with aeneous laterad (across near apex of 1, 3, along lower margin at distal $\frac{1}{2}$); tibia 1 beneath except each end, tibia 2 with a narrow, 3 with a wide middle cinctus. Funicle 1 longer than wide. Tibiae flavous at base and apex.

Type female, Kuranda, Queensland, November, 1919 (A. P. Dodd). Also at Gordonvale, March, December (paratypes in Queensland Museum).

A male from Kuranda had the cinctus of tibia 2 as wide as that of 3, and this may be true for the female.

In the collections of the South Australian Museum there is one female, Kangaroo Island (A. M. Lea).

2. **Platygerrhus froudei,** n. sp.

As *P. dugandani* but tibia 2 all yellow except for a short cinctus near base, wings clear, and postmarginal distinctly shorter than marginal and a bit over twice the length of the stigmal; distal $\frac{1}{2}$ of the tibiae yellow (frons moderately wide); funicle 2 three and a half times longer than wide, equal the elongate pedicel.

Gordonvale, Queensland, October, November, 1920 (A. P. Dodd). Cotype in Queensland Museum.

3. **Platygerrhus pallidicoxa,** n. sp.

As *P. incola* but smaller, funicle 2 subquadrate, distinctly shorter than pedicel, femora not *much* swollen, 1 not excised beneath and tending to be slender. All coxae pale. Scape rather widely aeneous at apex.

Three females, Kuranda, Queensland, December (A. P. Dodd). Cotype in Queensland Museum.

Genus Amerostenus Girault.

1. **Amerostenus varidentatus,** n. sp.

Mandibles 3- and 4-dentate, hence so characterised. Scape pale at base.

Otherwise like *A. aereipes* but first two pairs of tibiae aeneous above only, middle femur yellow dorso-mesad, postmarginal vein as in the genotype, that is, elongate, about twice the length of the stigmal, the latter with a long, slender neck. Joints of the funicle subequal, a bit wider than long, distinctly shorter than the pedicel. Propodeum short at the meson, there carinate. Thorax scaly reticulate, a few indefinite punctures, pronotum transverse, axillae advanced. Clypeus obtusely incised at each corner of apex. Tooth 3 of the 3-dentate jaw widely truncate, 4 of the other jaw obtuse and shorter.

Joint 1 of the middle and hind tarsi subelongate, much longest, in middle tarsus equal to the elongate tibial spur. The male similar but the fore tibia is entirely pale.

A male and two females from galls on the leaves of *Eucalyptus obliqua*, Blakiston, South Australia (T. D. Smeaton). Emerged May, 1888. With *Rhicnopeltella* and others.

Subfamily AGAONITINAE.

Genus Pleistodontes Saunders.

1. **Pleistodontes semiruficeps,** n. sp.

Like *P. froggatti* in structure of the antennae and head but entirely black, the head red except proximal (or dorsal) $\frac{1}{4}$ (from ventral eye ends), this part of the head, jet. Legs and first five antennals red-brown. Ovipositor not quite as long as abdomen.

Many females on Banyan figs, Lord Howe Island (A. M. Lea).

Subfamily PTEROMALINAE.

Genus Spalangiomorpha Girault.

1. Spalangiomorpha fasciatipennis Girault.

Two females from rice grain, Murray Island, Torres Strait. Two others labelled as being parasites of small beetles, June, 1891, Dr. Sterling, Central Australia.

According to Masi's table this genus is *Chaetospila*, the funicle being 5-jointed and the axillae separated. The species, so far, has not been referable to any older description, but I have not as yet seen all of them.

Genus Spalangia Latreille.

1. **Spalangia punctulaticeps**, n. sp.

Head densely rugulose-punctulate with many scattered umbilicate punctures. Wings dusky. A narrow median groove to the scrobes from the median ocellus. Funicles 1-3 wider than long, together about as long as the pedicel. Pronotum, scutum densely scaly with scattered pin-punctures on the former and also upon the scaly parapsides; a weak cross-row of fovea on scutum distad of the middle, from thence glabrous like the scutellum and axillae, and like these with a few punctures along lateral portions (on scutellum in two longitudinal rows, leaving a wide, smooth mesal area); a cross-row of pin-punctures on scutellum except at mesal part and toward apex; axillar sutures punctate. Propodeum with two foveate mesal grooves which join at middle and run as one to apex, narrowing much; glabrous but densely punctate laterad of the spiracle except at cephalic margin, this between the meson and spiracle foveate. Segments 2 and 3 equal, united half the surface, 4 a bit longer than either.

A female, Kangaroo Island (A. M. Lea).

Genus Pachyneuron Walker.

1. Pachyneuron kingsleyi Girault.

A female in October, Melrose, also at Gawler, South Australia (A. M. Lea).

Genus Pteromalus Swederus.

1. Pteromalus puparum (Linn.).

A female, Melrose, South Australia (A. M. Lea), in October; another by sweeping, Adelaide (N. B. Tindale).

Genus Paruriella Girault.

1. Paruriella australiensis Girault.

Two males, 5 females, Melrose, South Australia, October (A. M. Lea).

There were one or two thimble punctures on the scutum and scutellum in these specimens; the vertex bears numerous such punctures. Maxillary palpi 4-jointed. The male is like the female but joints 1-2 of the funicle are twice longer than wide, much exceeding the pedicel.

Genus Tomocera Howard.

1. **Tomocera io**, n. sp.

The same as *T. transversifasciata* but abdomen as in *T. saissetiae* (*i.e.*, above black with middle $\frac{1}{3}$ yellow), as are also joints 1-2 of the funicle, but 2 is quadrate (1 of funicle in *T. saissetiae* is not half the size of 2, which is longer than wide).

A female, from galls on leaves of *Eucalyptus obliqua*, Blakiston, South

Australia (T. D. Smeaton). Hatched May, 1888. With *Amerostenus varidentatus, Rhicnopeltella.*

The distal infuscation was faint, the few setae of the scutum short. Palpi 2-jointed, the joints subequal in each palpus and quite as in *T. saissetiae.*

Genus Roptroceropseus Girault.

1. **Roptroceropseus citripes,** n. sp.

As *Paruriella 4-dentata* in palpi, and so forth, but coxa 2 is aeneous, flagellum dark brown, propodeum four times wider than long, funicles subquadrate and equal the pedicel, tooth 2 of the jaw is largest. Differs from *R. albipes* only in the dark club and golden coxa 1.

The male has the scape foliaceously exfoliated rectangularly, funicle 1 distinctly exceeds the subglobose pedicel; there are 6 funicle joints all clothed with longish, stiffish hairs, 6 quadrate, club 2-jointed, conic and acute at apex.

Joint 4 of the maxillary palpus (female) is elongate, equal to the rest of the palpus. Middle tibial spur elongate, thin.

This genus belongs to the Miscogasterinae.

Several pairs from flower-galls of *Acacia pycnantha,* Norwood Gardens, South Australia, November 22, 1891.

Have also seen two females reared from galls on *Acacia aulacocarpa,* Cooroy, Queensland, August 6, 1928 (W. A. T. Summerville).

Genus Nasonia Girault and Sanders.

1. Nasonia abnormis Boheman.

A female, Mount Searle, Northern Flinders Range (H. M. Hale and N. B. Tindale).

The species has been synonomized recently with one of Walker's species. The genus *Mormoniella* Ashmead, or rather the name of a genus proposed by Ashmead has been substituted by some for *Nasonia,* but *Mormoniella* was never connected with a recognisable species, so that the name is but a name and nothing else. It was preferred merely because it preceded the name *Nasonia* by a few pages. Girault and Sanders subsequently based *Nasonia* upon the above species named by Ashmead *brevicornis,* but never described except by Girault and Sanders. Some years ago I became cognisant of the identity of *brevicornis* with the European *abnormis,* but before I could publish on the matter my notes were lost.

2. **Nasonia miltoni,** n. sp.

As *N. abnormis* but the clypeus slightly incised or bilobed at meson of apex, funicles 1-3 are longer than wide and 1 is distinctly smaller than 2, which is almost as long as the pedicel and longest; club 1 is longer than wide, half the length of the club and a bit longer than the pedicel; it exceeds any funicle joint. The post-marginal vein is somewhat shorter than the marginal. The scutellum bears obscure pin-punctures. The median carina is obscure and a spiracular sulcus is made impossible by a carina which crosses just behind the spiracle. Also segments 2 and 3 of the abdomen are large and equal, together occupying the same space as the larger 2 does in *abnormis.*

A female, Adelaide, South Australia (R. J. Burton).

Genus Isoplatoides Girault.

1. **Isoplatoides quadridentatus,** n. sp.

Two marks on fore wing, a wider one from the bend of the submarginal vein and basal marginal across, the other a substigmal spot from the apex of the stigmal vein to the middle of the wing and of moderate size. Parapsidal furrows complete.

Propodeum non-carinate, a fovea on cephalic margin about midway from meson to spiracle. As *I. quadripustulatus* otherwise. Jaws 4-dentate. Middle femur mesad more or less yellow.

A female, Barellan, New South Wales (A. M. Lea).

2. **Isoplatoides tripustulatus,** n. sp.

Like *I. bipustulatus* but furrows (apparently) *complete,* and there are three fuscous spots on the wing in a curved row from the bend of the submarginal vein to the apex of the stigmal vein; the third or distal of these is largest, toward centre and not touching the stigmal knob; the second is closer to the first. Wing otherwise is in the named species. (Head missing.)

A female, mounted with *I. bipustulatus,* and *I. bifasciatus,* South Australia (Macleay Museum). Type in the Macleay Museum.

Genus PSEUDANOGMUS Girault.

1. PSEUDANOGMUS FUSCIPES Girault.

A female, Parachilna, Flinders Range (Natural History Expedition).

The parapsidal furrows are visible only in certain lights. Propodeal spiracle elliptical, small. Clypeus strongly bilobed. The lateral ocellus is quite close to but not at the eye, twice closer to eye than to the median ocellus. The scrobes form an obtuse, deep, long median channel.

Genus ORMYROMORPHA Girault.

1. ORMYROMORPHA TRIFASCIATA Girault.

A female on *Atriplex,* South Australia; another, Bribie Island, Moreton Bay, Queensland (H. Hacker and A. M. Lea).

Genus MERISMOMORPHA Girault.

1. MERISMOMORPHA ACUTIVENTRIS Girault.

A female, Melrose, South Australia, October (A. M. Lea).

Segments 2 and 3 of the abdomen occupy not quite half the surface; in this specimen 5 was cross-linear, but I think the length varies according to whether or not the part is retracted.

Subfamily MISCOGASTERINAE.

Genus PAREROTOLEPSIA Girault.

1. PAREROTOLEPSIA PUNCTATIFACIES (Girault).

A female, South Australia, Adelaide (J. G. O. Tepper).

The lateral ocelli in this specimen were distinctly closer to the median than to eye.

2. **Parerotolepsia unimacula,** n. sp.

As *P. aereifemur* but wing with a distinct central blotch under all of marginal vein and touching apex of stigmal. Head, scutum, parapside with numerous scattered punctures. Clypeus produced, convex at apex. Lateral ocellus a bit closer to eye. Funicle 1 quadrate, a bit shorter than pedicel, rest wider than long. Scape metallic (so coxae and femora). Venation very dark, postmarginal equal stigmal, marginal swollen at base. Cross-suture scutellum distinct, not deep.

Propodeum with median carina only, spiracle small, round; discal cilia dense, nearly to base of marginal, none elongate; jaws black, red at apex, 2-4 distinctly shorter than the acute 1, 2 longer than 3 or 4, latter equal, obtuse. Maxillary palpus with at least two elongate apical setae.

A female, Adelaide, South Australia (J. G. O. Tepper).

Genus Systasis Walker.

1. **Systasis cecili**, n. sp.

As the original description of *S. doddi* (Girault), but the cross-suture of the scutellum is obscure, the cephalic parapside and cephalic $\frac{3}{4}$ of the scutum thimble-punctate as well as the upper head while the lateral carinae of the propodeum are distinct. The punctures of the scutellum are not along the meson widely. The space between teeth 2 and 3 of the jaw is finely serrate.

A female, Melrose, South Australia, October (A. M. Lea).

The cephalic tibia is green only dorso-laterad. The labial palpus is 3-jointed, joint 2 wider than long; the maxillary are at least 3-jointed. Abdomen distinctly exceeding the thorax.

2. Systasis varipes Girault.

Three females, Melrose, South Australia, October (A. M. Lea).

The scrobes in this species are short, semi-circular. The hind tibia in these specimens are green above for basal $\frac{3}{4}$ except at base.

Roptrocerella, n. gen.

As *Roptroceropseus* but the club only 2-jointed, funicle 7-jointed (antennae 12-jointed, excluding a very short, thin first ring-joint, inserted below the middle of the face but above eye-ends by a bit). Palpi 3- and 4-jointed. Jaws 3-dentate, but 3 is only a concaved truncation from the base of 2. Stigmal vein about half the length of the postmarginal, latter a bit shorter than the marginal which is distinctly shorter than the submarginal. Clypeus not produced, concave at apex. Abdomen no longer than the thorax, rather compressed and rounded. Scrobes elongate.

1. **Roptrocerella latipennis**, n. sp.

Blue-green, wings clear, knees, tibiae, tarsi, base of scape yellow. Funicle 1 somewhat wider than long, subequal the rest, half the length of the pedicel; club divided about middle, the joints nearly as long as the pedicel. Pronotum and scutum entirely umbilicately punctate, the punctures scattered over the axillae and parapside and a single line only down each side of the scutellum, latter without a cross-suture. Propodeum with a distinct median carina, the spiracle rounded, a bit away from cephalic margin, with a curved carina behind it and encircling it, no lateral carina. Fore and hind femora rather stout. Fore wing very wide, hind with 16 lines of discal cilia. Discal cilia of fore wing extending loosely to base, but there is a large, rectangular, naked area against the bend of the submarginal vein. Scutum pilose.

A female, Melrose, South Australia, October (A. M. Lea).

Genus Toxeumoides Girault.

1. Toxeumoides aeneicorpus Girault.

A female attracted to light, Rockhampton, Queensland (A. M. Lea).

The femora were entirely red, so they vary from red to subaeneous. Unfortuntely the head of this specimen was lost while mounting it, but I can scarcely doubt its identity.

2. **Toxeumoides poeta**, n. sp.

From the genotype: Cross-suture on scutellum before the apex; petiole very short; form wider; abdomen depressed and wide above, 2 a third or more of the surface, over twice the length of 3; propodeum without a median carina; the large pronotum laterad densely punctate and hairy, parapsides glabrous with punctures far laterad. Instead of the single fovea on cephalic margin of the propodeum toward the spiracle, there is a foveate grooved line extending as far across mesal base. Scutum naked.

A female, South Australia (Macleay Museum). Type in Macleay Museum.

3. **Toxeumoides silvensis,** n. sp.

From the genotype: Abdomen shaped as in *Perilampus,* segment 3 to apex, the petiole is thrice longer than wide, distinctly exceeding the hind coxa; scutum not finely cross-lined but scaly reticulate (finely cross-lined cephalad) and more pilose; propodeum opaque and scaly and without a tuft of long, fine hairs. Jaws shorter, teeth equal. Joint 4 of maxillary palpus with a single thick and club-like cylindrical terminal seta (in genotype several unequal terminal setae, none thickened).

A female, jungle, Montville, Queensland, June 14, 1924. Type in Queensland Museum.

Subfamily EULOPHINAE.

Genus Ardaloides Girault.

1. Ardaloides 10-dentatus Girault.

A female, Cairns District (A. M. Lea).

Coxa 3 was submetallic, segments 3 and 4 of abdomen above also whitish except lateral margins, jaws 11-dentate. The median groove of scutellum distinct. Axillae not advanced. Wings hyaline. Vertex with stiff, scattered, not elongate hairs. Maxillary palpi 2-jointed, apex with an elongate, stiff spine plus two short, unequal, stout lateral ones towards apex, the longer from the apex of a tubercle, the shorter from the axis. There is also a minute seta on the same side just below apex.

Genus Secodella Girault.

1. Secodella aenea Girault.

A female, Melrose, South Australia, October (A. M. Lea). Joints 1-2 of funicle a half longer than wide, distinctly exceeding the short pedicel.

2. **Secodella io,** n. sp.

In my table of species runs to *S. aenea* but differs: Joint 1 of the funicle a half longer than wide, rest quadrate.

All tibiae intense blue to apex; the second and third teeth of the jaw have a few faint serrations between them.

The jaws are tridentate; the maxillary palpi bear a flat, ovate apical spine. Abdomen conical, distinctly exceeding the thorax. Scape metallic.

One female, South Australia. Females, Owieandana, North Flinders Range (H. M. Hale and N. B. Tindale); Strahan, Tasmania (H. J. Carter and A. M. Lea); Vivonne Bay, Kangaroo Island (South Australian Museum Expedition, February, 1926).

Genus Diaulomorpha Ashmead.

1. Diaulomorpha australiensis Ashmead.

A female, Melrose, South Australia, October (A. M. Lea).

Legs except coxae and scape except apex, were golden. The postscutellum is not so large as I have described it.

Genus Entedonella Girault.

1. Entedonella aereiscapus Girault.

Three females, type locality and date.

Genus Pelorotelopsella Girault.

1. Pelorotelopsella australiensis (Girault).

A female, same place as recorded in Part I.; also two more females.

2. **Pelorotelopsella rex,** n. sp.

The same as *P. cinctipes* Girault but middle tibia entirely white.

A male, Mount Lofty, South Australia (J. G. O. Tepper).

The characteristics of this species, as taken from my table of species, are as follows:—Scape blue except extreme base; of tibiae, only basal $\frac{1}{4}$ metallic, all above in fore tibia except apex; first tooth of the mandible distinctly longer than the second. Bronze, joint 1 of the funicle thrice longer than wide, a stout, conspicuous spicule. Eyes hairy.

Disc of segment 2 of the abdomen is yellowish. Petiole nearly twice longer than wide, smooth. Second tooth of jaw only about half the length of the first. Scape compressed. Joint 1 of the funicle truncate at apex, joint 2 half the length of 1, its apex scooped out more or less. Hairs of joint 1 of the funicle not quite as long as the diameter of the joint.

Genus Metacrias Girault.

1. **Metacrias clara,** n. sp.

Brilliant bronze, the wings clear, legs except coxae and the scape yellow-white. Head and thorax densely, uniformly punctate, the caudal impression of scutum small, the furrows nearly complete. Joint 1 of the funicle a half longer than wide, ovate, exceeding pedicel, 2 similar but shorter, 3 globular equal pedicel and also 1 of the club. Joint 2 of the club smallest, its spicule short and stout; 3 of the funicle is wider than the pedicel. Second tooth of the jaw a half shorter than the first. Propodeum subglabrous, the median grooves deep, straight, moderately wide. Abdomen, from above, nearly round.

Characterised by the white legs and scape and unequal mandibular teeth.

Two females, Healesville, Victoria, April 12, 1929 (F. Erasmus Wilson). Type in collection of F. Erasmus Wilson; cotype in South Australian Museum.

Genus Euplectrus Westwood.

1. Euplectrus cairnsensis Girault.

A female, Lucindale, South Australia (A. M. Lea).

Genus Rhicnopeltella Girault.

1. **Rhicnopeltella sarah,** n. sp.

Funicle 2 a bit larger than 3, latter quadrate and two-thirds the pedicel. As *R. eucalypti* Gahan otherwise or nearly.

From leaf-galls on *Eucalyptus obliqua,* Blakiston, South Australia (T. D. Smeaton), April 23, 1888. Also galls on gum, Queensland (A. P. Dodd). A female, Mount Lofty, South Australia (A. M. Lea). This latter had joints 2 and 3 of funicle subquadrate but 2 smaller.

2. **Rhicnopeltella faunus,** n. sp.

As *R. eucalypti* Gahan but all tibiae purple, narrowly golden above or dorso-laterad; no patch discal cilia against bend of submarginal; funicles 2-3 equal in length and much longer than 1, not $\frac{1}{2}$ pedicel, latter and apices of funicles with some stout setae; differing markedly in the discal ciliation since its approaches marginal vein at distal $\frac{1}{2}$. Dark blue, male bright green, wing infuscation smoky against distal marginal and the stigmal.

A male, three females from galls on silver-leafed ironbark, Roma, Queensland, September 20, 1914 (H. Tryon).

3. Rhicnopeltella citritibiae Girault.

From *R. hegeli* (Girault): Funicle 2 a bit longer, 3 wider than long, only half the pedicel which is elongate; jaws bidentate. Bright green, antennae all black, no spot on hind tibia, funicle 1 only somewhat wider than long. Some stout setae from distal part of funicles; discal ciliation approaching the whole stigmal vein.

Three females in Macleay Museum from galls, Sydney, New South Wales. Types in Macleay Museum.

4. Rhicnopeltella immaculatipennis Girault.

Three females, Mount Lofty, South Australia (J. G. O. Tepper).

5. Rhicnopeltella purpurea Girault.

A female, Melrose, South Australia, October (A. M. Lea).

The discal ciliation of the fore wing in this species attains base of the stigmal vein. Mandibles equally, acutely bidentate.

6. **Rhicnopeltella depressa,** n. sp.

Abdomen depressed, ovate. Wing with a large substigmal blotch. Fore tibia golden except beneath. Knees widely, over distal ½ fore femur, intense lemon. Three ring-joints, the first shorter than the other two; three subequal, twice (or more) wider than long funicle joints (3 thrice wider than long), 3 not a fourth the length of the short, stout pedicel. Jaws bidentate. Antennae black, the club yellow beneath. Neck of stigmal vein shorter than the long-ovate knob. Middle tibial spur elongate, pale, spinose, much exceeding the first tarsal joint; hind tibial spur shorter, stout, long, a bit exceeding the metatarsus. Otherwise as in *R. faunus.* Setae of the vertex sparse.

A female, Tarcoola, South Australia (A. M. Lea).

Austrolynx, n. gen.

Similar to *Diaulinopsis* Crawford, but robust, head thick, jaws only 3-dentate postmarginal equal stigmal; tibial spurs stout, much unequal, 1 very short. Stigmal vein not elongate. Maxillary palpus 2-, labial, 1-jointed, former with 3, latter with 2 strong terminal setae.

1. **Austrolynx flavitibia,** n. sp.

Dark aeneous, wing clear, venation yellow, scape, legs, except basal two-thirds (sometimes less and usually only lateral aspect), femora and the coxae laterally, lemon; also the head more or less below the eyes. Finely reticulate.

Funicle 1 somewhat longer than wide, stout, equal pedicel, 2 quadrate; club 3 with a short, conic apical part bearing a short, stout spicule—this small part has the appearance of a fourth joint. Jaw teeth 1-2 acute, equal, strong, 3 oblique and with its apical margin feebly serrate. Vertex with numerous, scattered stout setae. Wing 2 with 12 lines discal cilia.

Propodeum at meson equal postscutellum, non-carinate. Spiracle round, rather small. Abdomen pointed, exceeding thorax.

The male is similar but the legs may be almost all yellow, the yellow of the head more distinct, venter of abdomen, dorsum of same above at base and distad in two marginal spots may also be yellow.

From several specimens of each sex mounted on a card with male *Rhicnopeltella* and *Eurytoma* and bearing the following data:—"Insects (10 kinds, 536 specimens) produced from one gall complexus collected by Mr. T. D. Smeaton

at Blakiston, South Australia, on *Eucalyptus rostrata*, April 23, 1888. Hymenoptera appeared till June 5 following"; and "From one small branchlet of red gum. No. 8 (small, black, etc.). From galls on leaves of *Eucalyptus obliqua*, Blakiston, April 23, 1888. Smeaton. Hatched in May." Another card, bearing paratype males, bore the data:—"9. Large and small brown. From galls on leaves *Eucalyptus obliqua*, Smeaton. Hatched May, 1888." A third card, bearing many females with male *Megastigmus* and *Eurytoma*, was labelled:—"9. Galls leaves *Eucalyptus obliqua*, 23/4/88. Blakiston. Hatched May 1888. Smeaton." A series of paratypes bore a similar label.

The species is associated with *Rhicnopeltella sarah* described above. Cotypes in Queensland Museum.

Genus Euplectromorpha Girault.

1. **Euplectromorpha lucia**, n. sp.

As *E. dubia* but scutum devoid of bristle-bearing pustules and of hair at over distal half (except one or two pustules, a pair cephalad and a pair caudad), so the axilla at over caudo-mesal third; head, thorax entirely black, antennae all yellow, joints of the funicle quadrate, 1 twice longer. Over distal third of the abdomen black.

A female, Kiata, Victoria, October, 1928 (F. E. Wilson). Type in the collection of F. Erasmus Wilson.

Genus Gyrolasella Girault.

1. **Gyrolasella aenea**, n. sp.

Green, wings lightly dusky at distal third; tarsi except last joint, knees, tibial tips, fore tibiae except below and the base of the tegula, pale; apex of the scutellum between the grooves, a dot on the prepectus, lateral margin of the axilla, margins around the base of the tegula, margin of eyes on face and (continuously) cephalic margin vertex, margin of the eyes (continuously) on vertex and upper occiput, golden. Densely scaly punctate including the non-carinate propodeum, the latter elevated mesad. Jaws 6-dentate. Joint 1 of the funicle twice longer than wide, 2 a third longer than wide, much exceeding the pedicel. Spicule large, its basal half or more stout, rest tubular. Stigmal vein long, clavate, subequal to the postmarginal vein. Flagellum armed with, besides others, stout, thorn-like setae.

A female, Carribie, Yorke Peninsula, South Australia (N. B. Tindale).

Genus Diaulomyiia Girault.

1. **Diaulomyiia nigroaenea**, n. sp.

As *D. asperitergum* Girault but dark aeneous, wings clear, (scape, legs except middle and hind coxae, tegula, dull red); spiracle with a delicate carina surrounding it behind; grooves of scutellum joined around the apex; somewhat smaller than the named species. Mandibles 8-dentate. Three bristles on scutum each side of the meson in an oblique or diverging line from cephalad.

A female, Adelaide, South Australia (A. M. Lea).

Genus Pseudiglyphus Girault.

1. Pseudiglyphus grotiusi Girault, **io**, n. var.

Differs from the typical form in having all tibiae concolorous at basal half.
A female, Mount Lofty, South Australia.

Genus NEOMPHALOIDELLA Girault.

1. Neomphaloidella eucalypti, n. sp.

Aeneous, wings clear; coxae, femora, antennae except basal half of the scape, concolorous; apices of femora 1-2 widely pale; joints of the funicle a half longer than wide and than the pedicel. Propodeum with a carina laterad of the spiracle and a median carina. Mandibles tridentate. Second wings with 13 lines of discal ciliation, obtuse at apex. Abdomen conic-ovate. Spicule distinct, small. Second two ring-joints very short. Abdomen exceeding thorax, acute distad.

A female from galls on the foliage of *Eucalyptus obliqua,* Blakiston, South Australia (T. D. Smeaton), May, 1888. Associated with *Neomegastigmus ater* and a male *Rhicnopeltella.*

2. Neomphaloidella brevistigma, n. sp.

Black, the wings very lightly infuscated from base to a point somewhat distad of the venation. Scape, pedicel, knees, tips of the tibiae, tarsi, fore tibiae except basal half above, pale, the club suffused yellowish; postscutellum and basal half of the abdomen obscurely yellow. Stigmal vein short, oblique, much shorter than the knob. Ring-joints large, increasing distad, the first only half the length of the third. Joint 1 of the funicle a half longer than wide, a bit shorter than the pedicel, 2 and 3 equal, a bit longer than wide. Spicule short and stout, clypeus bilobed. Teeth 1-2 of the jaws equal, acute, 3 small and distinctly shorter. Second wing with 10 lines of discal ciliation, wide, subobtuse at apex. Propodeum with a median carina only, this moderately long. Sculpture usual, *i.e.*, very fine.

A female, Ooldea, South Australia (A. M. Lea).

3. Neomphaloidella parkmani, n. sp.

As *N. octoguttata* but postscutellum yellow, joints of the funicle much unequal, 3 a third longer than wide, equal pedicel, 1 twice longer than wide. Also differs: Less slender, scape dull red, dark above, as is also the pedicel; femora 1 and 3 dusky, 2 less so; abdomen almost as in *Neotetrastichodes electra* but the basal yellow (segment 2, nearly $\frac{1}{4}$ surface) is absent, therefore there are but the four yellow spots on each side of the meson and commencing out from base, the first obscure and on segment 2 (therefore only three spots distinct); thus, also, the abdomen is as in *N. octoguttata,* excepting for the basal yellow. The first two ring-joints are shorter than the third (as in *electra)* but distinct. A distinct carina runs (like a lateral carina) from the lateral side of the cephalic spiracle. Maxillary palpus elongate. Jaw 3 obtuse and much smaller. No postmarginal vein. Clypeus strongly bilobate.

Propodeum scaly, with a median carina. Punctures along the lateral margin of the scutum distinct.

A female, Bribie Island, Moreton Bay, Queensland (H. Hacker and A. M. Lea).

4. Neomphaloidella bilobata, n. sp.

As *N. octoguttata* but not slender, antennae all black, legs yellow except coxae and femur 3, the dorsal yellow of the abdomen confined to the median line, of moderate width and from basal $\frac{1}{5}$ to base of the distal $\frac{1}{4}$ (apex segment 2, 3 5 or 6); joint 3 of the funicle is distinctly shorter than 1, longer than wide, subequal to the pedicel; joint 1 is twice longer than wide. Second ring-joint distinct, shortest, 3 longest. Propodeum densely, coarsely scaly, with a strong carina from the lateral side of the spinacle and a delicate x-shaped median carina; the forks of the x are not much diverged. Second wing obtuse at apex, very wide. Spicule stout.

Yellow of the dorsal abdomen dull, more or less obscurely broken at the apices of the segments. Scutellum with a grooved apex. Punctures present on pronotum (except caudal meson), lateral parapside and lateral margin of the scutum; these are distinct. Clypeus strongly bilobed. Maxillary palpus elongate, single (as usual for the group).

A female by sweeping, Mount Lofty, South Australia (A. M. Lea).

The metatarsus is subquadrate, shortest of the joints of the hind tarsus.

Genus Neotetrastichodes Girault.

1. Neotetrastichodes electra Girault.

Two females, Melrose, South Australia, October (A. M. Lea).

Joint 1 of the funicle exceeds the pedicel. The pronotum and lateral parapside are densely punctate and setigerous. In these specimens, the five cross-stripes of the abdomen were connected by a median line of black, and this blocks out a longitudinal line of yellow spots down each side of the meson (the margins are black to stripe 5); there is also a thin black stripe before (near) apex. The face is yellow down from the antennae. Maxillary palpi very elongate, 1-jointed. A short postmarginal vein. Clypeus strongly bilobed. The hind coxa was black only at basal half. Jaws tridentate.

In the original description neither the postmarginal vein nor the longitudinal stripe of the abdomen are mentioned, nor the black margins of the abdomen, but otherwise these specimens agree with it in every particular, and they have since been compared with the type (while revising the group).

The costal cell is naked except for a single line of cilia along close to the submarginal vein, the line complete and the cilia composing it slender. The discal ciliation extends to the base of the marginal vein. Ring-joints distinct, 3 largest and as in the Pteromalidae, all large and but three in number.

Genus Tetrastichus Haliday.

1. **Tetrastichus perobscurus,** n. sp.

Dull black; scape, knees, tibiae and tarsi pale; venation pale; lateral margin of the scutum cephalad, postscutellum, lateral margin of the scutellum, vertex more or less against the eye, yellow; abdomen above dull golden, the apices of the segments black (making 7 black cross-stripes, including one across base, 7 well before apex). Joint 2 of the funicle longest, a bit longer than wide, shorter than the pedicel, 1 quadrate, 3 wider than long; second ring-joint thinner than 1. Spicule small, flagellar setae moderate in length. Tooth 3 of the mandible distinctly smallest. Palpi single (as usual), maxillary subelongate, labial very short. Propodeum subtransverse at meson, with a median carina only (a carina just laterad of the spiracle). Sculpture very fine.

A female, Mount Pleasant, South Australia (Loveday), February 9, 1897. From galls.

In the specimen the median groove of the scutum was uncertain. It was very distinct but seemed to have been formed by a contraction of the body at the scutum. However, the species has characteristics which allow of its being easily recognised.

2. **Tetrastichus pontiac,** n. sp.

As *T. saintpierrei* but the yellow basal part of the abdomen has the base narrowly margined with black, and there is a marginal spot at middle and one toward apex. Moreover, the joints of the funicle are equal and barely exceed the pedicel (each about a fourth longer than wide), while the club plainly exceeds

the united length of joints 2 and 3 of the funicle. Spicule short. Scape white, antennae brown-black. Propodeum of moderate length at meson, with a median carina, the spiracle large.

Both palpi pale, single, the maxillary fully twice the length of the labial but not very elongate. Stigmal vein long-clavate. Jaws tridentate.

A female, Owieandana, North Flinders Range (H. M. Hale and N. B. Tindale).

3. TETRASTICHUS MITTAGONGENSIS Girault.

A female, Tasmania (A. Simson), No. 3581.

Scape red-brown. Clypeus bilobate, as seems to be usual for the Tetrastichini. One of the apical spines of the long maxillary palpus is shortened and depressed, forming a sword-shaped seta; the short, labial palpus is also thus armed. The second tooth of the jaw is rather deeply concaved, so that a third tooth is formed nearly. Lateral margin of the propodeum carinated. Lateral parapside and the pronotum finely sculptured. Second wing with fourteen lines of discal ciliation. Vertex and upper face with distinct punctures.

Genus TETRASTICHODES Ashmead.

1. **Tetrastichodes fuscitibiae,** n. sp.

Dark aeneous, legs and antennae concolorous except knees, tips of the tibiae, fore tibiae, tarsi and an obscure cinctus just before the middle of hind tibia. Postscutellum dull yellow except the meson widely. Propodeum with a (short) median carina. Joint 1 of the funicle twice longer than wide, somewhat exceeding the pedicel, 2 and 3 somewhat shorter; spicule distinct; second ring-joint very thin. Jaws tridentate. Palpi single, the labial much shorter than the other, both dark. Stigmal vein straight, rather long, the postmarginal a fourth or more its length. Mesal margin of the axilla narrowly lemon-yellow. With the usual sculpture. Flagellar hairs of moderate length, in several irregular rows per unit. Club nearly as long as the funicle. Setae from the marginal vein gross.

A female, Cradle Mountain, Tasmania (H. J. Carter and A. M. Lea).

Genus ASYNTOMOSPHYRUM Girault.

1. **Asyntomosphyrum limbus,** n. sp.

Black except lighter tarsi, the fore wing lightly clouded on basal $\frac{2}{3}$, especially opposite and beyond the marginal and stigmal veins, remarkable for their long fringe (which is a bit over a third their greatest width) and for their distinct, short postmarginal vein. Stigmal vein long and straight. Joints of the funicle a bit longer than wide, subequal to the pedicel but 3 shorter, globular; joints clothed with sparse, long hairs, a few on 3 very long. Spicule very long, the joints of the club exceeding funicle joint 3. Tooth 3 of the jaw shorter than 2.

Clypeus subentire at mesal apex (unusual). Cheeks with a few longish setae. Second wings acute, 4 lines of discal cilia, its caudal marginal cilia distinctly exceeding the widest part. No punctures except obscure ones along the lateral margin of the scutum. Postscutellum rather large. Propodeum with a paired median carina only. Abdomen more or less scaly. Pronotum and lateral parapside with sculpture uniform with the rest and nearly bare.

A female, Cradle Mountain, Tasmania (H. J. Carter and A. M. Lea).

Genus QUADRASTICHODELLA Girault.

1. **Quadrastichodella nova,** n. sp.

Aeneus, wings clear, coxae and femora concolorous, also flagellum, scape yellow. Scape strongly clavate, at apex above beset with strong teeth (seen from

side, from above coarse, serrated sculpture), as is also the pedicel, latter as long as the funicle and nearly as long as the club. Joints of the funicle somewhat wider than long. Ring-joints distinct. Propodeum short at the meson, there with a flat median carina. Spicule distinct, not very large. Jaws strongly tridentate. Clypeus bilobate. Labial palpus moderately long. Postmarginal vein half the moderately short stigmal. Abdomen equal to the thorax in length, conic-ovate. Metatarsus subequal to the stout tibial spur and to each of the next two joints, 4 longer by far. A line of setae down the lateral margin of the scutum. Second wing obtuse at apex.

A female, Adelaide, South Australia; 2 females (Macleay Museum) from South Australia. The types are in the Macleay Museum.

Genus Goethella Girault.

As *Tetrastichus* but inner grooves of the scutellum, groove of scutum absent; lateral groove of the scutellum outside of the bristles, at margin. Ring-joints large, equal. Male antennae: Four funicle joints, three club joints; the scape with a conspicuous, mound-like ventral expansion whose obtuse apex is near the apex, the funicle joints each with a dense ring of very elongate hairs from near base. Third tooth of the mandible wide, obliquely truncate from near the base of the acute 2. Palpi single, maxillary rather long. Propodeum very short at meson, with a median carina, no lateral.

1. Goethella asulcata Girault.

Dark aeneous, wings clear; knees, tibiae, tarsi, scape pallid. Joints of the funicle quadrate, shorter than the pedicel, 1 a bit longer than wide. Spicule small. No punctures.

Joint 1 of the male funicle quadrate, others a bit longer, subequal to the pedicel and to the joints of the club; spicule stout, distinct; the very long hairs are also on joints 1-2 of the club but further from base. Legs in the male lemon-yellow, except hind coxa.

Two males, four females.

Subfamily ELASMINAE.

1. **Elasmus bellicorpus,** n. sp.

Described in my table of species as follows: Yellow, abdomen orange marked with green; setae on hind tibia in (3-5) sagittate areas; mesopleurum not with a large black spot or not mostly black; head mostly yellow, abdomen not with a large, round black spot before tip; scutellum entirely yellow, the scutum with much green and black; like *E. arumburinga* but jaws 5-6-dentate, more yellow on scutum, the green-black from the pronotum forming a wide median line on scutum to slightly beyond the middle where scutum and parapsides are entirely and evenly green. Propodeum entirely green except the cephalo-lateral corner, and so the vertex except along the eye narrowly and upper $\frac{2}{3}$ of the occiput; joints 1-2 of the funicle a third longer than wide, 3 somewhat longer. Green of the abdomen as follows: Lateral margin and meson at base, distal third, a blur (with reciprocal marginal blurs) in three places, apices of segments 3-5 (equally before apex and after base of abdomen, 3 is close to the distal black-green which commences toward apex of segment 6). The yellow on scutum is a square. Pronotum green, except lateral fourth (neck nearly to lateral margins).

The palpi are 1- and 2-jointed (maxillary).

A female, Grantville, Victoria (Queensland Museum).

2. ELASMUS DUBIUS Girault.

Two females on *Atriplex*, South Australia.

3. ELASMUS NAKOMARA Girault.

A female, Samsonvale, Queensland. Sweeping grass in forest, September 18, 1927 (A. A. Girault).

Genus EURYISCHIA Koebele.

1. EURYISCHIA UNMACULATIPENNIS Girault.

A male, two females, Magnetic Island, Queensland (A. M. Lea).

The male is similar to the female, but the legs, scape, pedicel and face are white. The scape bears a great convex, ventral, foliaceous expansion studded with seven stiff bristles along ventral margin; its fore wing is hyaline, the proximal edge of the discal cilia somewhat irregular. Maxillary palpi (male) apparently 4-labial, 2-jointed.

I had already described the male of this species from reared material in the Queensland Museum (H. Hacker).

2. EURYISCHIA COMPEREI (Ashmead).

A female, Owieandana, Northern Flinders Range (H. M. Hale and N. B. Tindale).

This was typical (with the middle tibia dark), but the infuscation of the fore wing was faint (often the case) and the postscutellum yellow. The species varies in wing infuscation and the colour of the antennae and middle tibia.

Genus EURYISCHOMYIIA Girault.

1. **Euryischomyiia setosa,** n. sp.

Hind and middle coxae black, hind femora and others above and below narrowly, black. Black, head and upper thorax, except the propodeum, spaces off the scutellum, cephalic axilla, pronotum at meson, cephalic parapside, basal and apical margins of the scutellum, orange; scutellum with 3 setae along each lateral margin; about cephalic half of the scutum setose, this setose area bounded, caudad by a cross-row of 6 bristles, 3 on each side of which the lateral two are gross; naked thence except for a bristle on the caudo-lateral corner. Two gross setae upon the backward spur of the submarginal vein, base and apex. Discal ciliation terminating at the base of the marginal vein, its basal margin sinuate.

A female, Melrose, South Australia, October (A. M. Lea).

Subfamily EUCHARITINAE.

Genus EUCHAROMORPHA Girault.

1. EUCHAROMORPHA VIRIDIS Girault.

Two females, Launceston, Tasmania (F. M. Littler), February 6 and January 26, 1916.

There was a median groove on the scutum in one specimen. The fringes of the fore wing are present. The whole abdomen is densely, minutely pilose. The mouth-plate is at least 4-digitate and the jaws 2- and 3-dentate.

Genus STILBULA Spinola.

1. **Stilbula quadri-digitata,** n. sp.

Aeneous, the wings clear, venation pale yellow, so the scape, pedicel, legs except coxae and femora (except apices) and the tegulae. Striate in the usual way, scutellum with a median groove, strongly bidentate at apex but not produced,

the teeth short. Petiole coriaceous, 2½ times longer than wide, with a lateral carina. Propodeum glabrous to the spiracular sulcus, with a thin median carina. Segment 2 the whole surface, glabrous but with a few pin-punctures ventrolaterad. Club and distal joints of the funicle yellowish.

Scape equal to joint 1 of the funicle, which, with the others is produced somewhat on one side of apex, twice longer than wide at apex; scape thrice longer than wide, equal club; joint 2 of the funicle a bit longer than wide at apex, 5-6 quadrate, 7 wider than long; antennae 12-jointed but the joints of the club are merely indicated by constrictions, no sutures. Dorsal thorax naked.

Discal ciliation dot-like, no fringe; stigmal vein perpendicular, not a quarter the length of the postmarginal vein. Costal cell with a more or less paired central line of cilia.

Mouth plate 4-digitate, digits short, about twice longer than wide.

A female, Ardrossan, South Australia (J. G. O. Tepper).

2. **Stilbula albipennis,** n. sp.

From *S. quadri-digitata:* The mouth-plate though longer than wide is blunt at apex and bears six elongate, pale spines (therefore, it is not branched into four short fingers each bearing a spine at apex and it does not widen distad). The scape is dark aeneous, funicles 1-3 equal, thorax densely punctate, venation and discal ciliation indistinct; and so forth. The antennae taper distad, 12 distinct joints.

Aeneous-black, wings transparent and nearly naked; discal ciliation very sparse, pale; pedicel more or less, flagellum after funicle 3, knees, tibiae except 3, apex of tibia 3, tarsi yellowish.

Head except clypeus, circularly striate. Thorax entirely closely but not coarsely punctate, finely so in middle of mesopleurum, the metathorax foveate, the projection forming an erect, blunt, strong tooth on each side. Femoral furrow deep, so the lateral sulcus of propodeum, former glabrous. Petiole punctulate, foveate proximad, 3½ times longer than wide, lateral margin narrowly carinated. Meson propodeum widely concave, no median sulcus. Abdomen below finely pitted. Scape twice longer than wide, subequal funicle 1, scaly. Funicles globular, smaller than the pedicel.

A female, Groote Eylandt, North Australia (N. B. Tindale).

3. **Stilbula albipetiole,** n. sp.

Purplish, fore wing lightly infuscated from about bend of the submarginal vein. Legs except coxae, petiole, tegulae, scape except beneath at base and pedicel, white, venation yellow-brown. Head circularly striate. Thorax foveate-punctate, this sculpture coarser and more or less longitudinally striate on metapleura; prongs of the scutellum moderately slender, exceeding the basal part. Abdomen above, from apex of 2 (about middle), and nearly all below, densely punctate (punctulate), the petiole stout, about twice longer than wide, finely, longitudinally grained, narrower at base. Propodeum with a median ruga, the lateral sulcus wide and deep, the "hump" forming a large, obtuse "tooth," erect. Postmarginal vein elongate, the stigmal perpendicular, thick, narrowing to apex; bend of the submarginal vein abrupt.

Discal ciliation distinct, not very dense, no fringes. Fore wing widest through the stigmal vein. Mouth-plate with 8 digits, the central pair shorter, each with an elongate, pale, stout spine, the whole much as in *S. octodigitata.* Scape (excluding bulla) twice longer than wide, a bit shorter than funicle 1, latter distinctly longest, equalling 2 plus 3. 12 hemispherical, next smallest after pedicel; joint 8 quadrate, rest decreasing distad.

From *S. octodigitata:* Petiole all white and much shorter, scape pale and longer, funicle 1 shorter; prongs of scutellum are not shorter than the basal part, the median groove of the scutellum is obscure, abdomen with distinct sculpture and so forth.

A female, Caramby, Victoria, on *Bursaria spinosa,* January 14, 1887 (J. G. O. Tepper).

Also a male in the Macleay Museum from South Australia. In this sex the petiole is nearly as long as the rest of the abdomen (about six times longer than wide) and with lateral margins carinated. The antennae are 12-jointed, each of the 9 funicles with a long ramus from the same side, of 1 and 9 these a bit shorter, joint 1 wider than long, equal the pedicel, 9 over twice longer than wide; scape over twice the length of the pedicel, thrice longer than wide, half the length of the club, the latter is long as ramus 9 and with a distinct tooth-like projection between middle and apex on the side opposite the rami.

The propodeum bears a narrow median sulcus instead of a ruga, the stigmal vein is pale and shorter, the discal ciliation fainter. The mouth-plate is 10-digitate but similar in size and shape to that of the female. Jaws 2- and 3-dentate. Otherwise the male is the same. Process of the scutellum about half the length of the scutellum. Basal part distinctly wider than long and shorter than the "teeth" in the female, the "teeth" in the male quadrate, equal.

4. **Stilbula octo-digitata,** n. sp.

Purple, rugoso-punctate, the wings clear, veins pale, abruptly black from near the apex of the marginal vein; legs except the coxae yellow-brown; femora darker, scape nearly concolorous. Petiole white with an aeneous cinctus at middle, smooth, five times longer than wide, swollen at middle; scape a fourth longer than wide, not quite half the length of joint 1 of the funicle, exceeding the subglobular pedicel; funicle 1 thrice, 2 twice, 3 one and a half times longer than wide; 8-10 subglobular, 7 quadrate and larger than 8; club or 10 not well defined, rounded at apex. Scutellum with a distinct foveate median groove, the furrows joining around the apex; bifids shorter than the basal part of the projection. Scutum with a less distinct median groove, the furrows joining around the apex. Lateral sulcus of the propodeum wide, more coarsely foveate than the convex mesal part, this latter coarser than the punctuations of scutum and scutellum. Tegulae yellow.

Plate of mouth 8-digitate, the digits rather long, tubular, the middle shorter, at apex each with a long, pale bristle which appears to be truncate at apex (except on middle ones) as in some Thysanoptera. They are stout. Abdomen ovate, a bit compressed, not upturned, exceeding petiole.

A female, King George Sound. The type is in the Macleay Museum.

Genus Psilogaster Blanchard.

1. Psilogaster pulcher Girault.

A female, Tasmania, No. 2936 (A. Simson).

Belongs to *Epimetagea* Girault. This sex agrees with the description of the male except that the club is somewhat longer than funicle 7. The lower face bears scattered pin-punctures. The mouth-plate is 8-digitate, digits long with elongate apical spines, the lateral longest but not projecting farther. On one side there was a short ninth digit. The glabrous area on the caudal parapside is rather large. Pubescence on the scutum very sparse.

Genus Epimetagea Girault.

1. Epimetagea magnifica Girault.

A female, Mount Lofty, South Australia (J. G. O. Tepper).

Funicle 1 a bit over half the length of the scape, a third longer than 2, nearly twice the length of the pedicel, a fourth shorter than the club, 7 exceeding the pedicel. Basal joint of the maxillary palpus very elongate, subequal to the 3-jointed labial palpus whose distal joint is longest. Mouth-plate 8-digitate, the digits long, exceeding the palmlike basal part. In the lateral aspect, segment 2 is a third (or more) of the surface, in the dorsal, all of the surface. Abdomen glistening.

2. **Epimetagea sanguiniventris,** n. sp.

As the description of *E. bicoloriventris* but the entire abdomen (except the petiole) except basal $\frac{1}{3}$ above crimson, legs except coxae and hind femora more or less laterad, venation, tegulae, scape, straw colour; rest of the antenna red-brown The glabrous area on the mesopleurum is cephalad. The scape distinctly exceeds funicle 1 (almost twice longer); funicle 1 is subequal to the club, nearly twice longer than 2 or 3, all thicker at apex. Petiole over twice longer than wide, punctate, lateral margin carinate. Dorsal thorax pilose. The propodeum not rugose but rugulose and the mesal edge of the deep spiracular sulcus is carinate. Antennae 10-jointed, club solid. Scutellum terminating in a small, subemarginate plate.

Mouth-plate 13-digitate, the digits elongate and with long, stout apical spines, which are usually shorter than the part bearing them and blunt at apex. At least one palpus 3-jointed, 1 and 3 elongate, 2 short. Discal ciliation minute, not very dense, fringes absent around distal margin, minute elsewhere and inset from margin.

A female, Mount Lofty, South Australia (J. G. O. Tepper).

3. **Epimetagea flavifemora,** n. sp.

Purple, legs except coxae, scape, pedicel yellow-brown, wings lightly embrowned, veins dark; abdomen black, dark red in a wide crescent from near meson of near apical end of 2 to and along upper distal half of the side of 2 at distal half (leaving apical margin of 2 black); and the short 3 (making a concave cross-stripe nearly as thick as the crescent, latter best seen from the dorso-lateral aspect). This second red is not at apex in the dorsal aspect.

As identified specimens of *E. rufiventris* Ashmead otherwise, but lower half of face glabrous with scattered pin-punctures, cheeks and upper head circularly striate; funicles 2 and 3 are longer in relation to 1, thrice longer than wide; area of the propodeum between the lateral sulci more finely rugulose and there is a weak, narrow median sulcus. There is also a median groove on the scutellum (not marked in either species).

Joint 1 of the funicle exceeds the scape, and 7 and 8 are nearly twice longer than wide (thus joints a bit longer than with the other species). Joints 7 and 8 are the distal two joints of the funicle.

A female, Camden, New South Wales; also Monaro. Types in Macleay Museum. The second specimen bore fuscous femora.

4. **Epimetagea aeneobrunnea,** n. sp.

Brown, the head and upper thorax (except propodeum) aeneous-brown, the flagellum except pedicel, dark; wings subhyaline. Head circularly striate, the striae not dense; scutum cross-striate at cephalic half, the striae curving concentrically caudo-laterad to the furrows, from centre longitudinally striate.

Parapside glabrous, lateral half and distal margin punctate rather coarsely. Axilla, scutellum rather coarsely long-striate, scutellum with distinct median groove.

Propodeum glabrous but a bit crinkled on the mesal part, with distinct median and lateral carinae, the lateral strongly curved off laterad as it goes toward cephalic margin and between its cephalic end and the margin, the spiracle is lost in a network of rugae, no groove. The lateral carina originates dorso-laterad, runs nearly straight caudad (and a bit mesad), then makes wide bend nearly straight mesad, thence by a long gradual bow-bend reaches apex; the first two curves are about equal, 3 longer.

Segment 2 of the abdomen is about half the surface, 3 short, darker, forming a dark bow across the abdomen its ends curving up into segment 2. Petiole thrice longer than wide, glabrous but with a stout carina down each side (lateral aspect).

Jaws 2- and 3-dentate. Mouth-plate 8-digitate, digits short and blunt, each bearing an elongate, stout spine; there is also a similar spine laterad of digit 2 of either side (as if from a third digit).

Scape over twice longer than wide, over half joint 1 of the funicle, latter nearly twice the length of 2, widening distad; 2-3 equal, longer than wide, rest short but the oval club nearly as long as 2.

Discal ciliation dense, dot-like to about the base of the marginal vein. Scutellum obtusely pointed, sans distinct plate or tooth.

A female, King George Sound. The type is in the Macleay Museum, Sydney.

Genus Chalcuroidella Girault.

1. **Chalcuroidella bispinosa**, n. sp.

As the revised description of *C. orientalis* but scape distinctly exceeding joint 1 of the funicle, general colour aeneous, mouth-plate 11-digitate (digits long, outer pair more divergent); stigmal vein yellow; legs except coxae, tegulae, scape yellow brown; rest of the antenna and femur 3 dark brown or fuscous. Abdomen red except basal $\frac{1}{4}$ above and a spot above just before apex. There is a small glabrous area near the centre of the parapside. Petiole wider at base, where it bears a long lateral spine on each side. Abdomen smooth but with many scattered pin-punctures. Face very pilose. A deep, wide fovea at the base of the scutellum between the axillae. Legs pilose.

A male, Mount Lofty, South Australia (J. G. O. Tepper).

The scutellum appears to be folded up at apex and the rolled-up part pressed into the other; from lateral aspect, there is a short tooth just caudad of the emarginate apical plate.

Genus Metagea Kirby.

1. **Metagea punctulativentris**, n. sp.

Reminds of *Tricoryna subsalebrosa,* but hind metatarsus is not thick and the scape is over half of funicle 1, latter equal to 2 plus 3, these $\frac{1}{3}$ longer than wide; the club, joint 10, constricted at middle, a bit longer than 9, 8 and 9 subquadrate.

As description of *M. kirbyi* Ashmead but abdomen densely pin-punctulate (except the long segment 2 above), its petiole only $2\frac{1}{4}$ times longer than wide and very finely long lineolated. Legs except articulations and the tarsi dark, general colour dark blue. A median groove on the scutellum and between the large axillae. Rugosity of the thorax not coarse, only medium, the smooth part of the parapside is the mesal half of middle part. Venation beyond the submarginal vein, pale. Pedicel wider than long. Propodeum with a median carina, transverse striae from it.

Jaws 2- and 3-dentate. The hemispherical mouth-plate bears a middle spineless digit and 4 or 5 on each side of it, all wide and obtuse, each bearing a long, colourless spine. Lateral ocellus twice closer to the median than to the eye, latter sparsely hairy. Discal ciliation distinct, very fine and rather dense, to about the base of the marginal vein (a bit beyond).

Three females, South Australia. Types in Macleay Museum.

Subfamily EURYTOMINAE.

Genus Eurytoma Illiger.

1. **Eurytoma murrayi,** n. sp.

The same as *E. brevipetiolata* but abdomen yellow on venter and lower half of the sides, femora 1-2 above, 3 (all) black (except ends), so hind tibiae above centrally; scape black on dorsal edge. Stigmal and postmarginal veins subequal, half the length of the marginal. Median channel unifoveate. The yellow triangles on the face of the male nearly coalesce except at meson just beneath antenna. Resembles *E. tasmanica* in everything except channel of propodeum, punctate parapside, its longer marginal vein and the colour of the legs. Funicles exceeding pedicel. Petiole in female a bit longer than wide.

Two pairs, Tasmania.

The distal part of the disc of the scutellum bears sparse punctures, the interspaces finely reticulated. The outer orbits in the male are yellow.

2. **Eurytoma cecili,** n. sp.

Characterised by the pointed, conic-ovate abdomen with 2 exceeding any other segment, then 6 and 7 which are equal, finely reticulate and each with several rows of thimble-punctures; segments 4 and 8 shortest, 3 equal 5 and less than half of 2 and a fourth shorter than 6. Base of scape, knees, tibiae, tarsi, apex of the ovipositor valves, apex of the pedicel, red-brown. Funicles 1-2 somewhat longer than wide, somewhat exceeding the pedicel. Venation black, the postmarginal vein somewhat exceeding the stigmal, three-quarters the marginal. Petiole quadrate, surface coriaceous, with ridged lateral margins. Segment 5 finely reticulate. Median channel very distinct, coarse, bifoveate. Femoral furrow cross-rugulose-punctate. Densely punctate, pubescent. Lower propleurum reticulate. Wing 2 broad. Body robust, long. Punctures on lower half of the cheek sparse, the area reticulate. Runs with *E. secunda* and allies.

A female, Vivonne Bay, Kangaroo Island (Museum Expedition), February, 1926.

3. Eurytoma aretheas Walker.

A female, Tasmania.

This species, in my revised table, runs in near *E. spes* and allies but differs in bearing no median basin on the propodeum. It also runs to *E. nigroculex* but aside from its normal abdomen, funicle 1 is shorter, as is also the petiole.

4. **Eurytoma nigroculex,** n. sp.

As *E. helena* but abdomen with a distinct petiole which is twice longer than wide, no propleural spot, funicle 1 is somewhat over twice longer than wide, twice the length of the black pedicel, lateral ocelli equidistant, venation brown, marginal vein twice the stigmal, latter a bit shorter than the postmarginal. Punctuation dense and uniform, the median channel bifoveate at basal $\frac{1}{2}$ only. Femoral furrow cross-striate and punctulate. Segment 6 of the abdomen is half the length of 5, latter a bit shorter than 2-4 united. Segment 6 is naked and subglabrous. Tegulae red, fore tibia red-yellow only at apex and along each side.

Somewhat as *E. aretheas* Walker (as identified) but segment 6 is short, very hairy and only about a fifth the length of 5.

A female, Carribie, Yorke Peninsula, South Australia (N. B. Tindale).

5. EURYTOMA TASMANICA Cameron.

Equals *Xanthosoma*. Two hind tibial spurs. A pair, Launceston, Tasmania, No. 2006. Labelled as this species in typewriting, and probably a part of the original material of Cameron's; the type locality is the same. The female agrees with the description, but there is a propleural spot in both sexes. The umbilicate punctures on dorsal thorax are noticeably sparser only on the scutellum at distal half and on nearly entire parapside which is finely reticulated; the scutum is finely cross-lined only on cephalic margin. Femoral furrow reticulate scaly. The middle femora beneath and tibiae 2 and 3, except base and distal $\frac{1}{3}$, are slightly blackish also. The abdomen is brownish along lower sides and ventum and also distad of 5, ovate, rounded above, 5 long, glabrous, over the length of 2-4 united, petiole quadrate. Propodeum with a shallow, bifoveate median channel. Marginal vein short, a bit exceeding the postmarginal, the still shorter stigmal not exceeding the length of its knob.

The male has the middle face up to the antennae, outer orbits flavous; hairs of flagellum exceed the distal joints only. In the female, segment 3 is longer than the linear 4, both united less than 2. Propodeum umbilicately punctate.

The species was lost. It resembles and is similar to the species of *Eurysystole*.

6. **Eurytoma striatifemur**, n. sp.

As *E. silvipuer* but the fore coxa on cephalic aspect, base of middle coxa also black, the abdomen above entirely black, except dorso-laterad centre of 5 and 6; femora 1 and 3 above except at each end, fore tibia centrally above, hind tibiae laterad except each end, black. Prothorax entirely red-yellow except face nearly to the margins, median line widely and a round spot between it and the lateral margins; head yellow except frons, scrobes, vertex and upper half of occiput continuously except margins of the eyes. Scape black above.

Postmarginal vein subequal to the stigmal, latter shorter than its rather large knob, latter dark. The fine rugulae in the median "basin" are from the lateral boundaries, while the flat meson is finely punctulate and has a median carina from middle to apex, no foveae at base but the latter is carinate.

A female, Melrose, South Australia, October (A. M. Lea).

7. **Eurytoma varivena**, n. sp.

As *E. striatifacies* but somewhat larger, venation lemon-yellow with the rather short marginal vein (thrice longer than wide) equal to the stigmal and somewhat shorter than the postmarginal. Median channel of the propodeum light (shallow), bifoveate and narrowing. Segment 5 somewhat exceeds 4 but not as long as 2-4 united. Abdomen compressed, its petiole quadrate, abdomen high toward base, not much longer than high there. Characterised by the venation.

The fore tibiae are yellow beneath, the funicles moniliform but exceeding the pedicel. Femoral furrow finely punctulate.

A female, Mount Lofty, South Australia (J. G. O. Tepper).

Compare also the species *E. aroueti* (Girault) which differs in having the three distal veins of the fore wing equal and no channel on the propodeum through the median basin; moreover, in this species *(varivena)*, the basin is ovate and concave. Ovipositor valves entirely black.

8. Eurytoma casuarinae Girault.

A female, Magnetic Island, Queensland (A. M. Lea).

The whole dorsum of segments 2-3 of the abdomen were black.

9. Eurytoma australia Girault.

Three males, six females, mounted together and labelled "Tasmania." In the male the hind tibia is all black except each end, and the hairs of the flagellum were distinctly longer than the diameter of the joints, shorter in typical forms. In the female, segment 5 of the abdomen equals 2-4 united and is over twice the length of 4.

I am loth to give the above male variation a name but the difference is marked enough. It may be a common variation.

10. **Eurytoma minutivespa,** n. sp.

As *E. leeuwenhoeki* but flagellum black, fore femur so only at basal half above, 2 beneath only, 3 lateral aspect only; venation yellow-brown. (See No. 11).

In my revised table, follows *E. mazzinii*.

A female, Owieandana, Northern Flinders Range (H. M. Hale and N. B. Tindale).

11. **Eurytoma leeuwenhoeki,** n. sp.

As *E. semifuscicornis* but a half smaller, abdomen more humped, 3 is shorter than 4, the subquadrate-ovate median basin shows no trace of a median channel except at base and is uniformly punctulate, there is no petiole, segment 5 is over twice the length of 4 and longer than 2-4 united, the antennae are entirely white (except the rounded pedicel above slightly), the funicles, though exceeding the pedicel, are subquadrate and equal. Venation very pale but of the relative lengths, the postmarginal vein nearly as long as the marginal. Femoral furrow densely punctate.

A female, Roper River, North Australia (N. B. Tindale).

12. Eurytoma pyrrhocerus Crawford.

Two females from a brown, oval cocoon of what appeared to be some Ichneumonoid Hymenopteron. The cocoon was about a quarter inch in diameter. This species differs from *E. semifuscicornis* mostly in bearing no basin upon the meson of the propodeum, instead a distinct median channel. This channel is cross-rugose. There are no other differences.

In these specimens segment 5 of the abdomen distinctly exceeded 4 (Crawford says 3 and 4, meaning 4 and 5, are nearly equal). There is, of course, variation here, due to the movement of the segments one within the other.

13. Eurytoma semifuscicornis Girault.

Six females reared from the bag of an *Entometa* moth, Adelaide, South Australia, February 8, 1897.

One of the specimens was only as long as the thorax of the others. The flagella were rather darker than usual.

14. Eurytoma filisilvae Girault.

Several pairs, Mount Pleasant, South Australia (Loveday); from galls and lerp, February 9, 1897.

The apparent male is black, antennae red distad, otherwise similar to the female; one specimen, however, had the antennae, legs and thoracic pleurum

except metathorax, red-yellow. There is usually considerable colour variation in the males of this genus.

15. EURYTOMA species.

Many males entirely red-yellow except the head (except mouth), pronotum at caudal meson, abdomen (often, except petiole), scutum, axillae, scutellum and often propodeum (and usually its median channel). Reared from galls, lerp and so forth, Mount Pleasant, South Australia (Loveday), February 9, 1897.

16. EURYTOMA TERRAE Girault.

Two females, Adelaide, South Australia.

The fore femora were blackish laterad except at apex.

Subfamily CALLIMOMINAE.

Genus MEGASTIGMUS Dalman.

1. **Megastigmus hilaris,** n. sp.

As *M. brachyscelidis* but hind coxa black only laterad and a middle lateral spot on the hind femur. Ovipositor a bit exceeding the body. The following yellow: Head except vertex (except orbits) and upper half of the occiput; prothorax except face and median line above widely (at middle of this, from each side, a short lateral projection); caudal half and lateral parapsides, prepectus; apex, scutellum and the transverse postscutellum.

Abdomen fulvous with five cross-bands of black from apex of basal ⅓. Scutellum reticulate, on scutum very fine cross-striation, setae equidistant. Propodeum non-carinate. Fore femur with a black streak along lateral disc. Antennae black, joint 1 of the funicle nearly twice longer than wide, 7 quadrate, equal pedicel in length.

A female, Lucindale, South Australia (B. A. Feuerheerdt).

2. **Megastigmus cecili,** n. sp.

The same as *M. longicauda* but seta 2 of the scutellum a bit closer to 1, abdomen flavous, orange above, with only three cross-stripes (none distad of middle), 1 really the converging lateral margins of the long segment 2 (at its distal half), 2 across base of segment 3, 3 mostly a marginal spot at base of segment 4.

Head, prothorax flavous; propodeum black only widely down the meson and the sutures (in type female only cephalic margin). Stigma ovate. No black on head except upon the occiput, circularly around the neck. Segment 4 also with a longitudinal marginal spot at apex. Distal funicle joint a bit longer than wide.

Two females, Murray Bridge, South Australia (A. M. Lea).

3. **Megastigmus pallidiocellus,** n. sp.

Ovipositor subequal abdomen, latter subpetiolate. Flavous, eyes green, ocelli colourless. Face with strong converging striae below; two transverse, narrow marks just cephalad of the propodeum; a mark caudo-mesad of the tegulae. black; a transverse mark each side meson before apex segment 2 of the abdomen, 3 above except apex and a shorter stripe across base of segment 5, dusky. Funicle 1 a half longer than wide, shorter than the pedicel. Vertex with black setae. Ocelli in a triangle, lateral equidistant between eye and median. Second setae of the scutellum twice closer to 3 than to 1. Sculpture very fine.

A female, Banyo, Queensland, sweeping mangrove, September 30, 1923. Type in Queensland Museum. A female, Ooldea, South Australia (A. M. Lea).

In this last specimen the eyes were reddish, the second seta of the scutellum

was somewhat (not twice) closer to 3 than to 1. Stigma small, elliptical. Another female, Adelaide, South Australia (R. Burton) was similar but the general colouration was orange, cheeks, legs and scape lemon, the second seta of the scutellum twice closer to 3, stigma wider. It is apparently true that the position of the setae on the scutellum varies somewhat, as also does the shape of the stigma.

4. MEGASTIGMUS SULCICOLLIS Cameron, **walsinghami,** n. var.

A pair, Mount Lofty, South Australia (A. M. Lea).

Ovipositor not quite as long as the body. The same as *M. sulcicollis* but no black upon the scutum or scutellum and the ovipositor is shorter. The male stigma is large and round and its flagellum beset with long, scraggly hairs, the funicle long, narrowing distad. In the female, the three setae of the scutellum are equally spaced, the abdomen more or less sordid, especially across middle. The male abdomen is black above, the propodeum black, the first funicle joint over twice longer than wide, pedicel small.

The variety is similar to *M. maculatipennis* but the setae of the scutellum are equidistant and the male antenna differs. The male of typical *M. sulcicollis* is not known.

5. MEGASTIGMUS SPENSERI Girault.

Many pairs from galls on the leaves of *Eucalyptus obliqua,* Blakiston, South Australia, April, 1888 (T. D. Smeaton). Hatched in the following May. Also three females, same label, April 23, 1888.

The yellow stripes on the abdomen in the male were usually absent.

6. MEGASTIGMUS MACULATIPENNIS (Girault).

Many pairs from Port Jackson figs (A. J. Coates), Sydney, New South Wales.

The females of these specimens usually had the spiracular sulcus black; the pronotum was orange except at or near the caudal margin. The male is similar but its abdomen bears six distinct black cross-bands, 5-6 close together near apex. Also in the male the propodeum is sometimes immaculate or even all black between the spiracles. Neck of the pronotum black. The stigma in the female of these specimens was ovate, not globular, but I do not think this a stable character in the genus, as already stated.

The peculiar colouration of the species of this genus and the lack of structural differences make them difficult to define, but the setae on the scutellum, colour and position of ocelli, length of the ovipositor and the colour of the setae are some characters that can be used, though all of them vary somewhat. The grooves on the scutellum, first used by myself, unfortunately have been found to form one of those characters which is indeterminate—one can never be sure. Therefore *Epimegastigmus* and *Megastigmus* must be worked together. There is, moreover, a genus or group hidden in *Megastigmus* based upon male characters; and as very few of the males are known, as yet, the fact adds to the perplexity.

Genus EPIMEGASTIGMUS Girault.

1. EPIMEGASTIGMUS FULVIPES Girault.

Four females, Melrose, South Australia, October (A. M. Lea); one female, Adelaide (N. B. Tindale).

The stripes on the abdomen are near the apex of segment 2 (broken at meson) and most of 3 and 4 (hence well within basal half of the whole, 3 being about the middle). In one female, the setae on one side of the scutellum were equally spaced. The flavous colour varies: Sometimes the scutellum is nearly all flavous,

also the pronotum. The bands on the abdomen were very distinct in these specimens and vary from 2 to 3. On account of the flavous borders of the scutellum and parapsides, the above specimens were highly coloured and beautiful.

The species *E. limoni* Girault was at first thought to be but a duller form of this species (sometimes I cannot see the tibial grooves on the scutellum, a shadowy character). The only real difference between the two (females) is that in *E. fulvipes* there are 4-6 closely-set setae in the oblique line of discal cilia from the submarginal vein, while in *limoni* there are only 2, these well spaced; but in the males this character does not vary.

2. EPIMEGASTIGMUS TRISULCATUS Girault.

Three females, Tasmania.

The ovipositor was longer than usual by one-fourth. The median carina of the propodeum absent in all of these specimens except one where it was evident at basal and apical fourths, the interval filled by a diamond-shaped ruga. In all, there was a more or less distinct cross-carina on this region, but the rugulae vary here. The abdomen was black except at each end, but this colouration appeared to be due to oil in the body.

In a fourth female, from the same locality, although the abdomen was as just described, yet the two cross-stripes were faintly discernable and the blackening is not natural in life. The stigma is round-ovate.

Still a fifth female, Launceston, Tasmania, October 8, 1916 (F. M. Littler), was similar to the fourth, except that the ovipositor was a fourth shorter and the lateral margin of the propodeum and the mesopleurum behind the femoral furrow were orange. There was also a black spot in front of the lateral ocellus. There is considerable minor variation in colour and the sculpture of the propodeum varies.

3. **Epimegastigmus banksiae,** n. sp.

The same as *E. bucklei* but scutellum trisulcate, sculpture fine, margins of upper occiput delicate; head, prothorax, apex of the abdomen and legs also lemon; occipital black and that of upper scape narrow, no black otherwise on head; no other black except cephalic margin of the propodeum, as also the lines of its sulci, a line at the base of the tegulae and two faint cross-stripes beyond middle of the abdomen. (Flagellum missing.) No real sulci on propodeum.

A female, the Grange, South Australia, from galls on *Banksia* (A. Zietz), 1899.

Genus NEOMEGASTIGMUS Girault.

1. **Neomegastigmus leai,** n. sp.

As *N. auritibiae* but scape yellow narrowly ventrad only, head up to the antennae and the cheeks golden; coxae concolorous except the apex of 1, rest of the legs golden except middle laterad of the fore femur, femora 2 and 3, apices of the femora golden. Scape obclavate. A row of thimble-punctures along the lateral margin of the scutum and on each side of the meson of the scutellum far laterad. Scutellum cross-lined like the scutum. The same otherwise. Named for Mr. Arthur M. Lea.

A female, Kangaroo Island (A. M. Lea).

Genus PODAGRION Spinola.

1. **Podagrion metatarsum,** n. sp.

Scape at base, legs except lateral fore femur, most of middle femur except beneath and hind femur, venter of abdomen more or less, fulvous. Median carina of the propodeum forking beyond middle, the forks nearly at right angles.

Antennae black. Joint 1 of the funicle somewhat longer than wide, distal one quadrate, as long as the pedicel. Club not enlarged. Femoral teeth large, columnar, 2-3 longest, 4-6 usually coalesced, short and terminal, six teeth.

Male similar with pale and simple metatarsi (metatarsus not by far half the length of the tarsus and not or but scarcely flabellate). Hind tibia not clavate.

Two males, one female, Melbourne, Victoria, February 22, 1909. From the eggs of the mantid *Orthodera.* Also many specimens of both sexes with the same data and bearing the No. 39.

2. **Podagrion flabellatum,** n. sp.

Aeneous; legs and antennae flavo-fulvous except middle of the lateral aspect of hind coxa, venter of abdomen brown. Hind femur slightly marked aeneous. Joint 1 of the funicle quadrate, shorter than the pedicel, distal three joints much wider than long. Carina of propodeum forking out from base. The male has joints 1-2 of hind tarsus flabellate, equal, together half the tarsus; they are also red-yellow. The male hind tibia is clavate and its body red-yellow, as follows: Antennae, legs except a long spot on hind coxa near middle base of lateral aspect, tegulae and abdomen except distal $\frac{1}{4}$. Four femoral teeth (male), the distal 2 smaller and coalesced.

A male, two females reared from what appeared to be galls, Launceston, Tasmania (F. M. Littler). A gall-like vegetable object was mounted with each specimen.

In this genus, the metatarsus in the male varies considerably.

Genus Pachytomoides Girault.

1. **Pachytomoides bicinctus,** n. sp.

As *P. frater* but distal half of segment 2 of the abdomen, red, a second black band at apex, joint 1 of the funicle a bit longer than wide, 2 and 3 quadrate, 8 twice wider than long; hind coxa, hind femur on lateral aspect, aeneous; propodeum with a median carina that forks at middle, punctate distad of the fork, rugulose proximad of it. Discal cilia of the first wing extending far toward base. Femoral teeth 10, 1, 3, 6, 8, largest, 5 minute, 10 wide.

A female, Launceston, Tasmania, April 1, 1916 (F. M. Littler).

The fore tibia is much prolonged from one angle of apex.

Genus Macrodontomerus Girault.

1. Macrodontomerus triangularis Girault.

A female, Gawler, South Australia (A. M. Lea).

2. Macrodontomerus alighierini Girault.

Two females, Tasmania.

Genus Amonodontomerus Girault.

1. **Amonodontomerus montanus,** n. sp.

The same as *A. arboreus* but the pronotum with four rows of punctures, on scutum punctures sparse but over the entire surface (disc) and there are punctures on the mesal margin of the parapsides; segment 4 (abdomen) subequal to 2; legs except coxae, red; median carina of the propodeum obscure; ovipositor $\frac{2}{3}$ the abdomen. A line of setae down the facial eye margin, curving over to the apex of the clypeus. (Both flagella missing.)

A female, Mount Lofty, South Australia (J. G. O. Tepper).

Genus Ditropinotella Girault.

1. Ditropinotella compressiventris Girault.

Males, females, Tintinara, South Australia, from galls upon *Eucalyptus* (J. G. O. Tepper), January 6, 1887, and March 2, 1887. Also from galls upon *Eucalyptus obliqua*, foliage. Blakiston, April 23, 1888 (T. D. Smeaton). Emerged in May, 1888. Females.

Amongst the first lot were males. This sex bears purple legs except tarsi, scape entirely metallic.

Subfamily TRICHOGRAMMATINAE.

Genus Lathromerella Girault.

1. Lathromerella chinderaensis Girault.

A female, labelled "Cherry Gardens, South Australia (H. W. Andrew). Seeds of *Calamagrostis aemula*" and mounted with several male tetrastichines.

Subfamily MYMARINAE.

Australomymar, n. gen.

The same as *Polynemoidea* but the club is solid.

1. **Australomymar aurigerum,** n. sp.

Black, the three large sclerites between scutum and propodeum, proventer, neck of and the space between median carinae of propodeum, petiole gold-brown; legs suffused with same colour; wings light smoky with a not wide band across at bend of the submarginal vein; scape long and slender, nearly as long as the fore femur, about eight times longer than wide (excluding the long bulla), twice the length of joint 1 of the funicle which is nearly twice the length of the pedicel, latter equal to joint 4; joint 2 elongate, longest, over $\frac{2}{3}$ the length of the (body of the) scape and over six times longer than wide; 3 $\frac{1}{3}$ shorter than 2 and somewhat longer than 1, 4 and 5 each distinctly shorter than 1, 6 shortest. Fringes a fourth widest, 20-21 lines discal cilia extending to base of marginal (except a line or two). Ovipositor as long as the body. Scutum, parapsides coarsely scaly. Scutellum subquadrate, coriaceous; a rugulose, hemispherical sclerite follows it; postscutellum narrower, tricarinate, wider than long; propodeum long, with a pair of well-separated median carinae diverging to about middle, then converging. Hind tibiae densely beset with elongate hairs above. Metatarsus elongate but not half the length of the tarsus.

A female, Warragul, Victoria, 30, vi., 1929. In lichens and moss (F. E. Wilson). Type in collection of F. Erasmus Wilson.

Subfamily CHALCIDINAE.

Genus Chalcis Fabricius.

1. Chalcis rubripes Girault vergilii Girault.

A male, two females, Launceston, Tasmania, February 12, 15, and January 11, 1914, respectively (F. M. Littler, No. 2255).

2. Chalcis rufifemur Girault, var.

A male, Mount Lofty, South Australia (R. J. Burton).

The disc of hind coxa above was red, while the fore tibia was dilute red with yellow ends.

3. CHALCIS RUFICORNIS Girault.

Same record as in pt. i.

The distal yellow on the hind tibia was very obscure.

4. CHALCIS VICTORIA Girault.

A female, Norwood, South Australia, reared from wattle galls, April, 1892 (J. G. O. Tepper); a female, Pegenozena, Tasmania, December 31 1915 (F. M. Littler).

The amount of black on the tegulae and legs varies somewhat.

5. **Chalcis decens,** n. sp.

About the size of *C. shakespearei* and runs to that species and also (ignoring antennal insertion to *C. dipterophaga*). Fore wings missing.

Black, the following parts dilute red: Hind legs except for two yellow ellipses above on tibia at base and apex (the basal one longer than the red proximad of it and distinctly shorter than the red central red), abdomen beneath and lower sides of 2; fore and middle tibia except each end and on middle ones except ventro-laterad on one side (fore and middle femora diluted with red, apex rather widely in fore femur). Tegulae yellow. Antennae a bit above the ends of the eyes not distinctly above as in *dipterophaga*, which has conspicuous yellow apex of the hind femur, while the hind tibia is black where the red is in this species. There is a golden dot on lateral hind femur at ventral apex.

A female, Ardrossan, South Australia (J. G. O. Tepper).

6. CHALCIS PLUTELLOPHAGA Girault, **nortia,** n. var.

The same as *C. australiensis* but fore tibia yellow except above, except at each end. Hind tibia with no black at base.

A male, Launceston, Tasmania (F. M. Littler), January 2, 1917.

7. CHALCIS RUBRIPES Girault.

A male, Mount Lofty, South Australia (N. B. Tindale); and a female, same place (J. G. O. Tepper); two females, Lucindale (B. A. Feuerheerdt and A. M. Lea, separately); a male, Launceston, Tasmania (No 2255 of F. M. Littler).

In the Lucindale specimens nearly all of the fore femur and distal half of the middle femur were red. In the Tasmanian male, the fore femur except distal fourth and the middle femur except apex, were black. The black of the first two pairs of femora varies considerably in amount.

8. **Chalcis redia,** n. sp.

As *C. veronesini* but fore tibia with no black (red, above at each end, golden), the middle tibia is black on one side (the same side with yellow on each end); the abdomen as in *Stomatoceras* (that is, less convex and shortly stylate at apex); basal yellow of hind tibia a mere dot and, of course, smaller than the distal yellow. Femora 1-2 widely red at apex.

A female, by sweeping. Adelaide, South Australia (N. B. Tindale).

The lateral ocelli are somewhat closer to the eye than to the median ocellus.

There are several species of this genus that have the abdomen as in the above species (*e.g., C. pomonae* Cameron), but I am not sure as to the stability of this character. However, I have never seen variations of it.

Genus Chalcitelloides Girault.

1. Chalcitelloides io Girault.

A female, Blackall Range, Queensland (A. M. Lea).

This species is the same as *Chalcitella australiensis* Girault described originally as bearing no tooth above on the hind tibia. It seems the tooth was ignored or overlooked and later searched for and found. Hence the error. The name *australiensis* takes precedence. Middle coxa red.

Genus Xenarretocera Girault.

1. Xenarretocera v-carinata Girault.

A female, in flood debris, Adelaide, South Australia (A. M. Lea).

In this specimen the wings were clear, apex of segment 3 of the abdomen somewhat concave. The second and third longitudinal rugae of the propodeum converged and joined at about middle, thence united; they, therefore, formed a sort of Y. Punctures of the scutum smaller and denser than those of the scutellum, latter well spaced.

2. **Xenarretocera murrayi,** n. sp.

Exactly similar to *X. v-carinata* except for the nearly equal punctuation of the scutum and scutellum, there being no wide mesal spaces upon the scutellum; moreover, the interspaces are not glabrous but finely reticulated.

A female, Owieandana, Northern Flinders Range, South Australia (H. M. Hale and N. B. Tindale).

Genus Stomatoceras Kirby.

1. **Stomatoceras parvivespa,** n. sp.

Runs to *S. longicornis* but antennae black, joint 1 of the funicle slightly reddish and not quite as long as the pedicel, segments 2-5 red and all of venter; thus differs primarily in having more red upon the abdomen. There is a cross-stripe from the marginal vein, the usual loop from this and an infuscation from this loop to wing apex (except caudad). From *S. salti* (types compared): More of the abdomen red, the wing infuscation, funicle 1 is distinctly longer. The species *salti* differs from *S. dipterophaga* in the formation of the femoral teeth —at first a straight line (not quite a half from base), then a long, gentle convexity, the whole occupying a half or more of the ventral margin.

A female, Beverley, Western Australia.

2. **Stomatoceras disconiger,** n. sp.

Runs close to *S. minor, omphale,* and *maeterlincki.* From *minor:* The legs except (as usual for the genus) fore coxa and the whole of the lateral disc of the hind femur and the fore femur obscurely dorso-laterad, red; funicle 2 black at distal half; wing not lightly dusky to apex from the strong loop; postmarginal vein a bit shorter than the marginal; abdomen entirely black. From *omphale:* By the large, discal black on the hind femur, by having the second joint of the funicle red at base, abdomen all black; teeth of the hind femur on distal $\frac{2}{3}$, the proximal convexity small, the other long and gradual. From *maeterlincki:* Hind coxa red, hind femur with the discal black; teeth of the scutellum strong.

Segment 2 is practically glabrous, half the surface, a short carina on each side of meson at base (also present in *S. parvivespa* and, doubtless, all of the species).

A female, Dorrigo, New South Wales.

3. **Stomatoceras vespella,** n. sp.

As *S. melitarae* but differing primarily in the femoral teeth, which are on a bit more than distal half, proximad a long, gentle convexity occupying about $\frac{1}{2}$ plus, at first straight but after middle forming a slight mound; then, nearly as long, a prominent, much higher convexity whose sloping (distal) side is much longer than the mound part, which is at the basal end. Also, legs except fore coxa, red, segment 4 (of abdomen) black above; pedicel, joints 1-3 of the funicle red (pedicel short as in *S. dipterophaga)*.

A female, Adelaide, South Australia.

4. Stomatoceras salti Girault.

Distal half of segment 2 and all of 3 above are red. This variety is now considered a species.

AUSTRALIAN COLEOPTERA. PART VI.

By Albert H. Elston, F.E.S.

[Read October 10, 1929.]

Family ELATERIDAE.
Subfamily CONODERINAE.

Conoderus arbitrarius, n. sp.

Elongate; moderately thick; subopaque; upper surface dark brown with the head and the anterior margin of the pronotum slightly diluted with red, the under surface mostly reddish-brown, antennae and mouth parts ferruginous, legs testaceous; rather densely clothed with short, sericeous, depressed, cineraceous pubescence. Head flattened in forepart, with a very small carina on the vertex, anterior margin rounded, with densely arranged, small rugose punctures; antennae just extending beyond apex of posterior angles of the pronotum, the first and second joints small, subglobular and about equal, the both combined a little more than half the length of the fourth, with a fine carina extending the whole length. Scutellum elongate and obtusely pointed behind. Pronotum longer than wide, lightly and evenly convex, the longitudinal median line almost obsolete, the lateral margins from base to near anterior margin almost imperceptibly, rectilinearly converging, and then lightly, roundly contracted, lateral margins of anterior angles curved towards underneath, the posterior angles long, acute, produced backwards but scarcely diverging, bicarinate, the inside carina equally as strong as the outer but only half its length; with densely arranged small round punctures. Elytra across shoulders slightly narrower than pronotum across posterior angles, sides almost parallel from behind shoulders to near the middle then gradually, roundly attenuated to apex which is briefly, obliquely truncated at the sutural angles; punctate-striate, the punctures in striae moderately deep, elongate and contiguous, the interstices relatively wide, flat and minutely, subrugosely punctured. The prosternum at the sides lightly furrowed through the deflexion of the lateral margins of the pronotum. Length, 12·5-13·5 mm.; width, 3·5-4 mm.

North-Western Australia: Kimberley (J. S. Clark; Dr. E. Mjoberg). Type in author's collection.

Near *C. brunnipes* Schwarz, from which it can be distinguished by its more uniform colour and with the legs testaceous.

Subfamily CORYMBITINAE.

Poemnites nitidicollis, n. sp.

Elongate; nitid; black, antennae reddish-brown to blackish; elytra testaceous (with exception of apical part which is black), legs fulvous; moderately densely clothed with short, depressed, cineraceous pubescence. Head flattened in forepart with closely arranged, moderately large, subrugose punctures; antennae with ♂ extending beyond the base of the pronotum, that of the ♀ barely reaching the posterior angles of same, the second joint very small, the third about twice as long as the preceding and about the same length as the fourth, feebly serrated from the latter joint with the apical one simple. Pronotum slightly longer than wide, rather strongly and evenly convex, with a very feebly marked longitudinal median furrow, sides from near the base almost straight and parallel up to the anterior

third then gradually roundly contracted, posterior angles acute, produced backwards and slightly divergent, carina short and not strongly marked; moderately densely covered with sharply-defined, round punctures. Scutellum subtriangular and acutely pointed posteriorly. Elytra across shoulders barely as wide as pronotum across posterior angles and a little more than twice the length of the latter, rounded at the humeral angles with the sides almost straight and parallel to near middle then strongly attenuated to apex, depressed in the sutural region; punctate-striate, the punctures in striae relatively large, round and contiguous, interstices narrow and subrugose. Length, 6-7·5 mm.; width, 1·5-2 mm.

Queensland: Cairns (F. P. Dodd); Herberton, Malanda (Dr. E. Mjoberg). Type in South Australian Museum.

This is a very distinct and pretty species; the blackish part of the elytra is very variable, hardly two specimens being alike, it ranges from the tip of the elytra, with the suture and the lateral margins narrowly infuscated, to the whole of the posterior half being black and in most cases this dark portion is continued upwards for a short distance along the suture and lateral margins. Its nearest ally would be *P. australicus* Cand., from which it may be distinguished by having the whole of the under surface, the posterior angles of the pronotum and the apex of the elytra black.

Subfamily LUDIINAE.

Agonischius aulacoderus, n. sp.

Elongate; narrow; subnitid; dark castaneous with the elytra testaceous, head, antennae and scutellum blackish, parts of pronotum, suture, lateral margins and punctures in striae of elytra more or less infuscated; moderately densely clothed with a pale, sericeous pubescence. Head lightly convex with a small, shallow, interocular depression, with densely arranged, very small, round punctures; antennae reaching back to about the middle of elytra, moderately strongly serrated (♂), second joint very small, joints three to eleven about equal in length, the apical one tubular and narrower at the base than at the apex. Pronotum longer than wide, evenly convex, slightly wider at the base than at the apex, lateral margins almost straight, the longitudinal median furrow distinctly visible along the whole length, posterior angles slightly divergent, produced backwards and acute, sharply carinate; densely covered with very small, round punctures. Scutellum elongate, sides curved, posterior acute, minutely punctured. Elytra cross shoulders about the width of pronotum across posterior angles and about thrice the length of the latter, slightly depressed near the suture, sides straight and gradually contracted to near the posterior fourth then somewhat more abruptly contracted to apex which is rounded, rather finely punctate-striate, the punctures in striae round and not crowded, the interstices narrow, lightly convex, finely and minutely punctured. Length, 8 mm.; width, 2 mm.

New South Wales: (E. W. Ferguson); Queensland: Glen Lamington (Dr. E. Mjoberg). Type in author's collection.

The forepart of the head is more or less reddish, the base and region of the longitudinal furrow of the pronotum is infuscated and the base of the elytra is bright testaceous. Its nearest congener is *A. mjobergi* Elston, from which it may be distinguished by the black head and antennae, infuscated pronotum, the latter furrowed along the whole of its length and the clothing of same longer and of a silky appearance.

Family CLERIDAE.

Subfamily CLERINAE.

Cleromorpha albohirta, n. sp.

Convex; subnitid; black with the two basal joints of the antennae and trochanters reddish, legs in parts more or less diluted with red. Clothed with

long (almost tomentose) whitish hairs. Head lightly convex on top and depressed in the forepart; with rather coarse, densely arranged, subrugose punctures; antennae moderately slender, apical joint reaching back to about the base of pronotum, first joint large, the second about half the length of the third which is not quite as long as the fourth and fifth combined, nine and ten are enlarged and obconical in shape, the eleventh elongate and attenuated at the apex. Pronotum wider than long, sides evenly curved with the widest distance apart near the middle, anterior and posterior margins straight; with closely arranged, moderately large and deep punctures. Scutellum very small and round. Elytra across shoulders wider than base of pronotum and about thrice its length, sides from behind shoulders gradually, almost imperceptibly, dilated to near the posterior fourth and then more or less abruptly, roundly contracted to apex; punctures closely arranged in rows, rather large, deep and subreticulate, becoming smaller and more shallow towards apex. Length, 3·5-4 mm.

Victoria: Melbourne (E. Fischer); South Australia: Murray River (A. H. Elston). Type in author's collection.

This and the following species more or less resemble the genotype, *C. novemguttata* Westw., in all the salient characteristics with the exception of the antennae, in the former these appendages are slightly longer, more slender and only the last three joints enlarged so as to form a club, whereas in the latter the club is distinctly composed of four joints.

Cleromorpha ruficollis, n. sp.

Convex; subnitid; black, except basal joint of antennae which is more or less reddish, prothorax reddish testaceous, legs testaceous with the tarsi slightly infuscated. Moderately sparsely clothed with long, white hairs. Head almost flat and densely covered with small, rugose punctures; antennae moderately slender with the apical joint reaching back to near the base of the pronotum, the second joint a little less than half the size of the first and bead-like in shape, the third joint about twice as long as the second and slender, the fourth much smaller than the third, joints four to eight about equal in length with each other, nine and ten enlarged and subconical, the apical joint about as long as the ninth and tenth combined, wide at the base and attenuated towards the apex. Pronotum wider than long, lightly and evenly convex, the anterior and posterior margins about equal in length, the lateral margins abruptly, roundly dilated near the middle; with closely arranged, moderately large, deep, round punctures. Scutellum very minute and round. Elytra across shoulders distinctly wider than base of pronotum, sides almost straight and parallel to beyond the middle then roundly contracted to apex; with large, deep, seriate punctures, becoming smaller posteriorly and almost obsolete near the apex. Length, 3·5 mm.

South Australia: Quorn (A. H. Elston). Type in author's collection.

In general outline this species closely resembles *C. albohirta* Elston, but may be easily distinguished by its colour.

Odontophlogistus similis, n. sp.

Elongate; subnitid; black, the clypeus, antennae, palpi, eyes, abdomen and tarsi reddish; clothed with long, griseous pubescence, more densely arranged on the head and sides of pronotum. Head with two moderately large interocular foveae, the antennae not quite reaching the base of pronotum, the apical joint elongate and tapering to a point; with small, sparsely arranged, indistinct punctures. Pronotum much wider than long, sides roundly dilated at the middle, surface uneven with shallow depressions; with shallow, sparsely arranged, indistinct punctures. Scutellum small and subcircular. Elytra across shoulders

much wider than base of pronotum and about three and one half times as long as the latter, shoulders rounded and protuberant, sides slightly curved and roundly contracted on the posterior third; punctate-striate, the punctures in striae large, deep and subreticulate, the striae narrow and costate. Length, 8·5 mm.; width, 3 mm.

New South Wales: Culcairn. Type in author's collection.

In general appearance it closely resembles *O. rubriventris* Elston, but may be easily distinguished from that species by the colour of the antennae which is ferruginous and longer, the apical joint of which is more elongate and drawn out into a point; the punctures on the head and pronotum of the present species are barely visible, whereas on the former species they are deeply pitted.

Eleale aenea Elston.

A large specimen of this species, measuring 12·5 mm. in length, was taken near Melbourne by Mr. E. Fischer.

Eleale chloris Chev.

This species varies in colour from bright emerald green to green with brassy reflections; the antennae, mouth parts and tibiae are testaceous, the femora are mostly of the same colour as the body or darker and the tibiae are more or less infuscated; the apical joint of the antennae is very widely and deeply emarginated.

Subfamily HYDNOCERINAE.

Allelidea viridis Blackb.

Mr. F. E. Wilson has sent me two female specimens of the above species which he swept from rushes growing in a swamp at Altona, Victoria. These specimens agree very well with the author's description except for the colour which, instead of being "viridi-aenea," is a nitid piceous black.

Subfamily ENOPLIINAE.

Tenerus tumidicollis, n. sp.

Elongate; subnitid, head and pronotum reddish testaceous, the latter with a large, transverse spot on the anterior margin black, elytra testaceous with four large black spots, two basal and two apical, antennae, mandibles and legs black; moderately densely clothed with rather long, semi-erect pubescence, golden on the pale parts and black on the dark parts. Under surface testaceous with the metasternum black. Head with two small, shallow, interocular depressions, with closely (but not densely) arranged small, shallow punctures; antennae robust, the second joint small and subglobular, the third quite three times as long as the second, the following strongly serrated except the apical which is acuminate at its apex. Pronotum about as long as wide, the anterior margin rounded and very narrowly recurved near the middle, the lateral margins curved and from near the middle gradually, roundly contracted to the base, in the middle near the base with a rather large, shining tumidity; somewhat more densely punctured than the head, the punctures similar to those on the latter. Scutellum small and almost circular. Elytra across shoulders barely wider than pronotum at base and about thrice the length of the latter, sides almost straight and parallel to near apex then roundly contracted, with two fine costae on each elytron, one close to the suture and extending from behind the scutellum to nearly the whole length, the other beginning at the base—about midway between the suture and the humeral angle—and

barely reaching the middle, these are joined together at the base by a short, curved third costa; densely, finely and subrugosely punctured. Length, 8·5 mm.

Queensland: Brisbane (H. Pottinger). Type in author's collection.

This species should be easily recognised by its distinct colour markings; the two black basal spots on the elytra touch the lateral margins but not the suture, the two apical ones touch both the suture and the lateral margins.

Tenerus parvus, n. sp.

Elongate; opaque; black, pronotum testaceous except lateral and anterior margins which are black; densely covered with very small, black pubescence except on pale part of pronotum where it is golden. Head with a shallow depression near the base of each antenna, with densely arranged, minute punctures which are concealed by the clothing; antennae long and robust, second joint small and globular, the third only a little longer than the preceding, the following strongly serrated except the apical one which is elongate and acutely pointed. Pronotum about as long as wide, the lateral margins lightly and evenly rounded, with a small tumidity at the base in the middle and an indistinct one on each side of the middle on the posterior third and situated about half way between the middle and the lateral margin; with punctures similar to those on the head and concealed by the clothing. Scutellum very small and circular. Elytra across shoulders barely wider than pronotum at base and thrice as long as the latter, sides almost straight and parallel to near apex then roundly contracted, without distinct costae, with densely arranged, minute punctures which are more or less concealed by the clothing. Length, 4·5 mm.

Queensland: Cairns. Type in author's collection.

Distinguished from all other Australian members of the genus by its small size; the sides of the head near the eyes are lightly diluted with yellow.

Subfamily CORYNETINAE.

Pylus okei, n. sp.

Subnitid; dark castaneous, antennae and legs a little paler; moderately clothed with semi-erect dark pubescence. Surface of head even, densely covered with small, deep, subrugose punctures; antennae reaching to base of pronotum, apical joint almost circular. Pronotum about as long as wide, abruptly and angularly dilated on the sides at the middle, with a moderately large, round, deep depression in the middle near the anterior margin and two much less distinct ones near the base; densely and evenly punctured with rather large, deep punctures. Scutellum minute and rounded on the sides. Elytra across shoulders much wider than pronotum at base and about thrice the length of the latter, humeral angles almost square, sides almost straight and parallel to near apex then somewhat abruptly roundly contracted; closely covered with large, deep seriate punctures becoming a little smaller posteriorly. Length, 4·5 mm.

Victoria: Gypsum (C. Oke). Type in author's collection.

A much smaller species than *P. fatuus* Newm., and can be readily distinguished from it by the head not having an interocular fovea, with densely arranged and asperate punctures; the pronotum densely and subrugosely punctured, the surface less uneven, in *fatuus* the pronotum (particularly the anterior portion) is densely covered with minute punctures and the middle and sides interspersed with large, scattered punctures forming a double punctuation, the present species is densely and uniformly covered with large punctures. This species is at once distinguished from *P. pallipes* Macl., *inter alia*, by the apical joint of the antennae being almost circular and not drawn out into a spine at the apex, also the head and pronotum are more densely and coarsely punctured.

Pylusopsis, n. gen.

Body elongate, subdepressed. Head more or less rectangular and almost truncate in front; eyes prominent, moderately coarsely granulated, emarginate in front; mandibles moderately prominent and curved inwards; maxillary and labial palpi moderately long, the apical joint of each is similar in shape and size, elongate, narrow at the base and becoming widely dilated to apex where it is obliquely truncated; antennae robust, sometimes reaching back to base of pronotum, the first joint large and curved, the second small and almost globular, the third long and subcylindrical, four to eight about equal in length and subglobular, nine to eleven widely dilated and forming a loose jointed club. Prothorax about as long as wide, narrower at the base than at apex, with a moderately strong protuberance on each lateral margin near the middle. Scutellum very small. Elytra at base wider than pronotum, at base straight and subangular at the shoulders, strongly punctured only on the anterior half; apex of each elytron individually rounded and simple. Legs rather long and robust, posterior femora not reaching apex of abdomen, tarsi with only four visible joints, the first three joints with pads on the under surface, apical joint elongate and dilated towards apex; claws simple.

The granulation of the eyes is much finer than in *Pylus* and yet coarser than that of *Parapylus,* the sculpture of the pronotum and elytra is quite different from either; the formation of the apical joint of the maxillary palpi should at once distinguish it from either of these genera.

Pylusopsis chrysocome, n. sp.

Elongate; subdepressed; black with the elytra, abdomen and a narrow band at apex of pronotum ferruginous, the antennae black with the apical joint white and the tips of the apical joints of the black palpi also whitish, with a black spot on each elytron just in front of the middle, the under surface of the tarsi more or less testaceous; rather densely clothed in parts with long, shaggy pubescence, golden on the pale parts and black on the dark portion. Head with the surface even, densely and subrugosely punctured; antennae reaching to base of pronotum, second joint small and subglobular, the third almost as long as the fourth and fifth combined, joints nine to eleven dilated and forming a loose jointed club, the apical joint barely longer than wide and rounded. Pronotum about as long as wide, the basal margin somewhat narrower than the apical one, sides strongly dilated at the middle and forming a protuberance on each side, with three nitid protuberances on the disc, two behind the anterior margin—one on each side of the middle—the third is an elongate one in front of the base at the middle, the two in front joined to the posterior one by a more or less interrupted elevated, nitid line forming a Y; densely covered with small, deep punctures. Scutellum very small and more or less rounded. Elytra at base a little wider than pronotum, the base almost truncate, humeral angles slightly rounded, sides almost straight and parallel to near middle then roundly contracted to apex, with two large, slightly raised elongate protuberances at the base, one on each side of the suture, the anterior half with large, round punctures more or less arranged in rows, the posterior half densely, minutely (almost imperceptibly) punctured. Length, 5-6 mm.

Victoria: Belgrave; Gembrook (C. Oke); Millgrove (F. E. Wilson).

POLARITY IN CASUARINA PALUDOSA.

By Thomas T. Colquhoun, B.Sc.,
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(Communicated by J. G. Wood, M.Sc.)

[Read October 10, 1929.]

Introduction.

The fact that plants have polarity is generally accepted; but opinions differ widely as to whether this is stable or labile, and as to whether it is inherited, induced or impressed. Much work has been carried out on this subject, but owing to the contradictory nature of some of the results, there is still no definite answer to the problem.

Pfeffer (1) is of the opinion that polarity is first induced in the plant, and this is later impressed on the young parts by the parts preformed. This induced polarity may be retained by the cells to a greater or less degree so as to be apparently inherited.

Coulter and Chrysler (2), rather unconvincingly, conclude that polarity is non-existent.

Vochting (3) holds that it is a special property of the plant body, founded in the structure of the egg and is not induced by external agents.

These are the three extreme views, but many workers such as Sachs (4), Lund (5), Doposcheg-Uhlar (6), Miehe (7) and Neilson-Jones (8) have attempted to solve the problem. Most of these agree with Pfeffer's idea.

The latest work of which I am aware is that done by Neilson-Jones (8), who carried out exhaustive tests with roots of Seakale—*Crambe maritima.*

None of the work, so far as I have gleaned, has been carried out on *Casuarina paludosa.* (Sieb., in Spreng. Syst., iii., 803.)

Vochting (9) performed transplantation experiments with cubes of beetroot, and in this investigation methods somewhat resembling those of Vochting were used.

Technique.

Portions of the bark of Casuarina paludosa were taken off the stem, reversed, regrafted and allowed to grow. After growth had taken place from the bark, experiments were carried out with the shoots and finally sections of the graft were examined.

Method of Grafting.

This part of the work was carried out by Professor Ewart in August, 1927. The tree was a young seedling about four years old, growing in the System Garden in the Melbourne University grounds. It was in the open without any particular protection from the elements.

Portions of the bark, 3 inches by 2 inches, were removed, taking, as far as practicable, the cambium, but not lifting any of the wood tissues. The removed pieces were reversed, reapplied, the edges covered with grafting-wax and bound firmly against the trunk. The top of the tree was then removed, causing abundant formation of adventitious buds all over the main trunk, including the grafted portions, although there was only a limited formation on these. Only two of the

normal shoots were allowed to develop, and two or three on each graft of the bark. Of the latter, five developed fully and formed junctions with the wood of the tree.

At the same time, some bark was removed but not regrafted, the wounds being smeared with grafting-wax. This was done in order to see if any development took place from scraps of cambium which may have been left on the wood. As no development took place, it can reasonably be concluded that it was the same in the case of the buds, *i.e.*, that development took place from the bark, not from a fragment of cambium which may have been left on the wood of the stem at the time of removal of the bark.

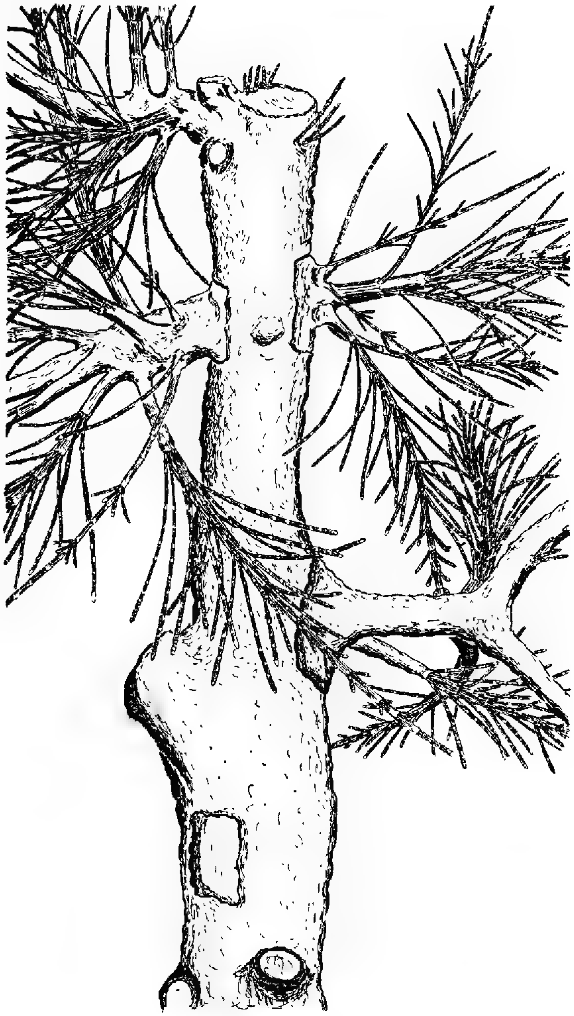

Fig. 1.

General view of upper portion of the tree, showing normal (top) and "inverted" shoots and parts from which the bark was removed.

Method of Growing the Shoots.

Strong, healthy shoots were selected from normal and inverted branches. Whilst they were still on the tree, the upper side of approximately similar-sized shoots were marked with indian ink. Shoots were cut off and passed through

holes in corks which were fastened into glass vials containing tap water. The vials were placed in various positions, the normal and reversed being placed in similar positions according to the marked side as follows:—

Some were placed vertical with the "root-pole" in water; others vertical with the "shoot-pole" in water.

Some were placed horizontally, half having the marked side uppermost, the other half having it downwards.

The specimens held vertically were placed under bell jars, together with an open dish of water to keep the air moist. The horizontal specimens were placed in large gas jars lying on their sides, all held in position with plasticine plugs. The ends of the jars were closed with vaselined ground-glass plates. The atmosphere in these jars was kept moist by a small amount of water being introduced into them.

Method of Sectioning the Graft.

The whole of one graft was sawn off the trunk and sawn into small portions for sectioning (see fig. 2 for pieces). Sections of pieces 1, 2, 5, and 6 were examined, thus showing longitudinal and transverse relations of the wood fibres in the graft wood and stem wood. The sections were hand cut and for clearer study were stained with safranin and light green.

The graft was removed from the tree eight months after it had been set.

Results.

Appearance of the Tree.

On wounds covered with grafting-wax, no growth took place. The shoots from the inverted grafts grew downwards, but turned up at their outer ends, in this respect varying in no way from some normal shoots (many of which developed after removal of the graft, and were then allowed to grow), which grew more or less vertically downwards for about a foot and had sub-branches which grew outwards but slightly downwards, turning up at the ends. In all cases, however, the shoots from the graft grew downwards, whilst the normal shoots growing down were in the minority.

Growth of Shoots.

The growth of shoots gave no results whatever. Despite care and the provision of moist conditions, the shoots all died after about a month and were then attacked by various fungi. This part of the experiment was first started on April 7, 1928, but after non-success, new shoots were not set up till Spring, on September 6. A third set was started on October 8, and another lot on November 12. In no case, however, did the shoots show any sign of root development. This part of the experiment was suggested by Pfeffer's (1) experiments with Salix.

Examination of Sections.

Sections of "1" transverse to the line of graft, *i.e.*, longitudinal sections of the wood, showed an interesting development. At the line of junction of the scion and the stock, there was considerable derangement of the wood elements. The inner stem fibres and vessels were undisturbed, but the few outer, newly-formed vessels were twisted, forming a callus-like mass. The junction of the stem and scion fibres was not direct, but in all cases there seemed to be a twisting or bending, some of which are figured (see fig. 3).

The sections of "2" and "5" showed nothing so outstanding. There was abnormality of tissues due to the callus-like growth, but only transverse sections of the vessels and fibres showed.

Sections of "6" showed somewhat similar formations as those of "1." The wood fibres were considerably twisted in the stem wood, but the fibres in the branch did not appear to be in any way disturbed, growing out normally from the more recently-formed (though twisted) stem wood (see fig. 4).

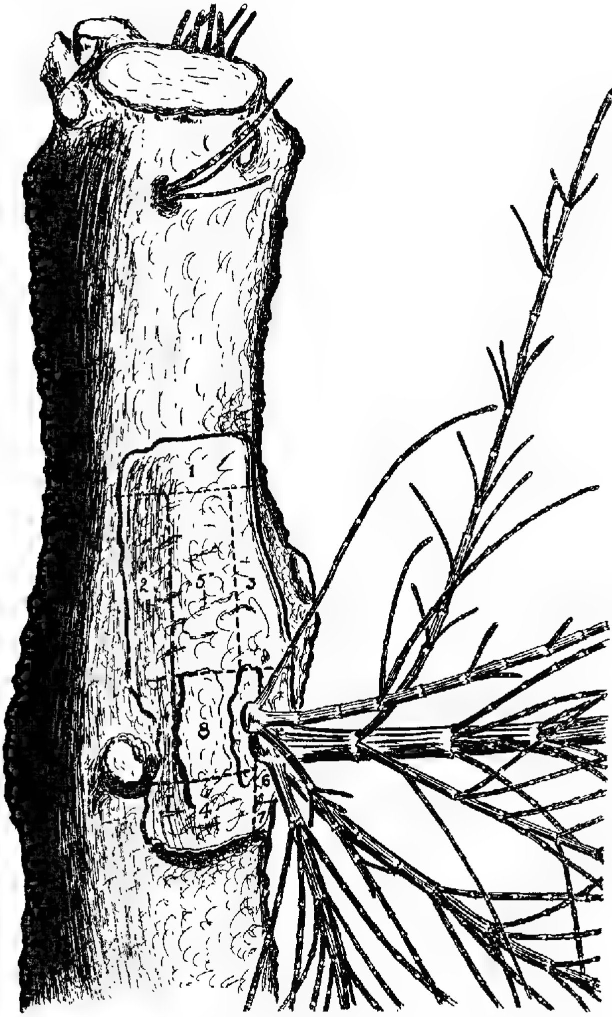

Fig. 2.
View of the graft which was removed for sectioning, showing the parts into which it was sawn.

Discussion.

In the tree, growth seemed in no way to be checked by the inversion, the inverted branches being as strong as the normal ones and equal to them in length and diameter.

The tests of shoot growth were intended to show if root development was altered in any way by the inversion of the shoots. Owing to no growth taking place, this part of the work is inconclusive. The turning of the wood vessels, however, seems to show that there must be some effect. The absence of any hindrance to growth seems to indicate that the cambium cells are quite capable

of function and continued growth and development in spite of their inversion. But this is not so in the wood fibres. The twisting effect is the same as that noted by Vochting (9) in 1892 when he experimented with cubes of beetroot, removed and replaced. It appears as though the ends of the "reversed" vessels are unable

Fig. 3.

Microphotograph of section of "I" transverse to the line of graft, *i.e.*, a longitudinal section of the wood. The twisting of the vessels at their points of junction is well shown. (Section stained with safranin and light green and photographed in blue light. Magnification × 63.)

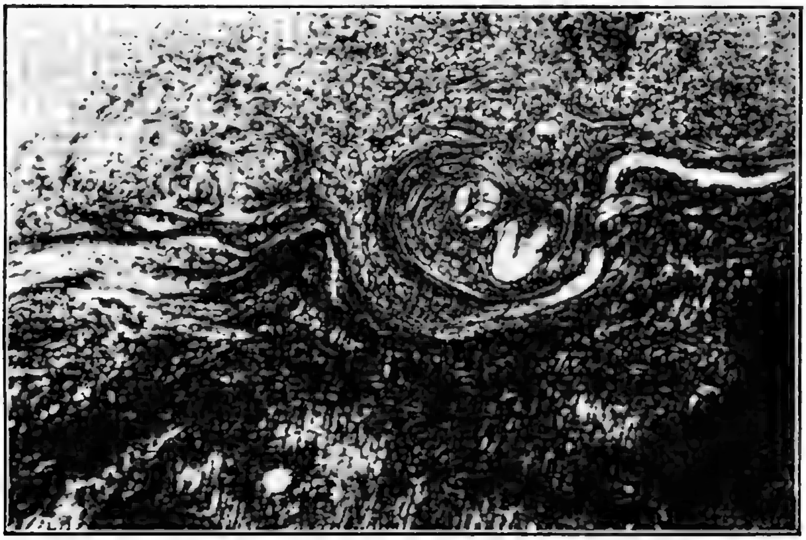

Fig. 4.

Microphotograph of section of "6" below the branch. This shows disarrangement of the fibres in the stem wood below the point of origin of the branch. (Section stained with safranin and light green and photographed in blue light. Magnification × 63.)

to unite with the opposite ends of the others. Thus they try to orientate themselves with the original vessels by bending over at the ends and making a junction.

At the time of grafting, however, no wood was lifted. Therefore, the wood formed by the cambium after resetting must have caused the callus growth and twisting of fibres. It seems, therefore, that the cambium, whilst joining freely, must have had some polarity, and this was impressed on the wood formed by it. The cambium divides tangentially, and each cell is surrounded by similar undifferentiated cells which cannot, therefore, exercise any polarity influence upon one another in respect to structural origin. The cells receive their food materials from the wood or phloem in a tangential direction, so that they can have no verticibasal polarity of translocatory origin and are consequently not disturbed by the reversal. On the other hand, the fibres and vessels, the latter particularly, have a definite relationship with one another in the process of translocation and water conduction. If the newly-formed "inverted" parts had no polarity it would be easy for them to join end to end with the normal parts. But the vessels twist on themselves. This seems to be an effort to keep translocation and water conduction in the same orientation in regard to the original position or polarity of the vessels. This polarity must have been impressed upon them by the cambium cells. Therefore, the evidence of this work, so far as it goes, agrees with Pfeffer's idea.

SUMMARY.

1. Buds of *Casuarina paludosa* grafted upside down, grow without any apparent check or effect.
2. Up to date, cuttings have not given rise to roots when grown in water culture.
3. Longitudinal sections of the wood transverse to the line of graft show twisting of the fibres and vessels.

This work was carried out in the Botanical Department of the University of Melbourne whilst holding the Caroline Kay and Howitt Natural History Scholarships for 1928.

In conclusion, I wish to thank Professor Ewart for allowing me to carry on the investigation started by himself, for advice as to the method of investigation and for helpful criticism throughout the work.

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FLORISTICS AND ECOLOGY OF THE MALLEE.

By J. G. Wood, M.Sc.
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[Read October 10, 1929.]

Introduction.

The present paper is the result of a study of the mallee scrub, extending over six years, and includes observations made in the Murray Mallee (the area in South Australia extending from 37° to 32° south latitude), Yorke Peninsula, portions of Eyre Peninsula, outliers of the mallee in the North-East of South Australia, and also in the Millewa and Wimmera districts of Victoria and the mallee regions north of the River Murray in New South Wales.

Fig. 1.
"Mixed Community of Mallee *(Euc. oleosa)*, Saltbush and Bluebush at Dilkera, showing typical habit of the Mallee.

The term mallee is a native one and refers to a habit of growth. The first published record of the name is in "Australia Felix," published in 1848 by W. Westgarth, who states that "the natives of the Wimmera prepare a luscious drink from the *laap*, a sweet exudation from the leaf of the mallee *(Eucalyptus dumosa)*." The term, however, was probably in common use amongst the settlers at this period.

Mallee scrub is typical of hundreds of square miles of country in Southern Australia, the chief tree covering being various species of the genus *Eucalyptus*. The most important species are *Eucalyptus dumosa*, *E. oleosa* and *E. gracilis*, while more locally are found *E. incrassata*, *E. calycogona*, *E. angulosa*, *E. leptophylla*, *E. cneorifolia*, *E. Flocktoniae*, *E. Behriana*, *E. diversifolia* and *E. pyriformis*. All these species are small trees varying in height from about two to twelve metres, and all with a characteristic habit of growth. From a main underground rootstock several stems arise which branch sparingly and bear leaves only at the ends of the branches. This results in the formation of a canopy-like collection of

leaves. The coppiced habit and canopy top are the two outstanding features which give the *facies* to the whole of the area.

Associated with the *Eucalyptus*, spp., are commonly found the "native pines," *Callitris robusta, C. verrucosa, Casuarina lepidophloia,* and various shrubs and undershrubs of a xerophytic type. The ground flora is largely ephemeral and is present only after rain. For the greater part of the year the ground beneath the trees and shrubs is bare (see fig. 1).

Practically no previous work relating to the ecology of the mallee has been published, though floristic lists have been made by Tate (7, 8, 9,) and Tepper (11) in South Australia, and by Hardy (3) in Victoria. Adamson and Osborn (1) studied a mallee community at Ooldea. The floristic lists given in the appendix to this paper are compiled from the above-mentioned sources, from the author's field notebooks and from Black's "Flora of South Australia." The nomenclature throughout is that of Black's "Flora."

FACTORS DETERMINING THE DISTRIBUTION OF THE MALLEE.

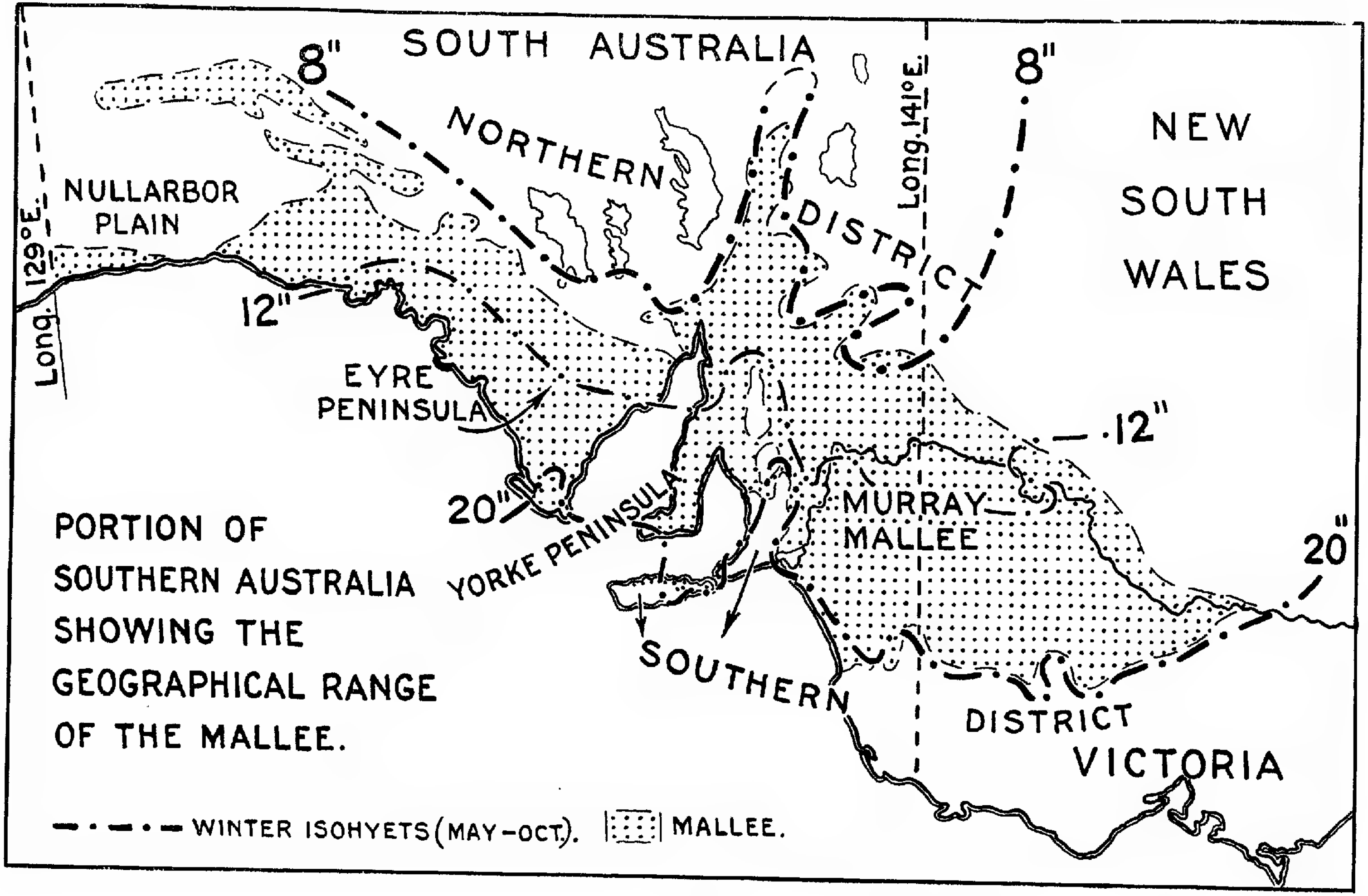
1. Climatic Factors.

The geographical range of the mallee is shown in the accompanying map, which is based on Prescott's admirable vegetation map of South Australia (4), and from the data contained in Year Books for the States of Victoria and New South Wales, as well as the Floras of those States. The two main regions are the Murray Mallee (including parts of South Australia, Victoria, and New South Wales on either side of the River Murray, as shown on the map, and thus extending this term, well known in South Australia, to include a portion of Victoria) and Eyre Peninsula, with Yorke Peninsula lying between them. All this country has an elevation of less than 500 feet. Geologically, the Murray Mallee consists of late Tertiary deposits, whilst Eyre Peninsula is of Recent origin. The soils are of the arid type known technically as "Solonetz" soils, and without exception consist of sands and silt covering nodular travertine limestone deposits. Sometimes the limestone forms compact masses, and not infrequently outcrops at the surface.

The considerations brought forward in this paper will show that the mallee is a formation characteristic of alkaline semi-arid soils and sharply delimited by amount of rainfall.

Reference to the map will show that the Mallee Formation is limited on its northern boundary by the 8-inch rainfall isohyet, and on its southern boundary by the 20-inch isohyet. This refers particularly to the greater portion of the mallee which is in South Australia. Practically all the rain falling over this area falls from May to October, and is produced from winter and spring storms arising in the Southern Ocean. The mallee is essentially a community arising from winter rainfall within the limits specified. The factor of winter rainfall determines the northern limit of the mallee in New South Wales. In the Western Plains of the latter state the 8-inch isohyet turns northward, encircling the central arid region, and rainfall becomes controlled by an entirely different set of storms. Here the mallee does not follow the isohyet as it does in South Australia. The northern limit is determined, approximately, by the northern limit of winter rainfall which runs in a north-westerly direction from Cape Howe to Broken Hill and then west-north-west to Shark's Bay in Western Australia. Above this limit the mallee is replaced between the 8- and 20-inch isohyets by savannah.

As regards rainfall reliability, the whole of the mallee area lies within the territory bounded by the isopleths showing 15% to 20% variation from the average amount of rainfall, indicating a semi-arid type.



PORTION OF SOUTHERN AUSTRALIA SHOWING THE GEOGRAPHICAL RANGE OF THE MALLEE.

2. Edaphic Factors.

The mallee soils are "Solonetz" types, and are invariably alkaline. They show great uniformity over the whole of the area considered, and do not differ markedly from the arid soils of the north-eastern and central regions of South Australia as far as the latter soils have been examined. These last-named soils support, usually, saltbush *(Atriplex,* spp.) and bluebushes *(Kochia,* spp.), with their attendant flora.

Mallee, saltbush and bluebush soils all have in common a surface layer of varying thickness underlain by grey or buff-coloured soils containing nodular travertine limestone; the nodules vary in size in different soils.

Both pure saltbush soils and mallee soils have approximately the same water-retaining capacity. The amount of water at saturation in soils from different localities is given in the following table:—

Locality.	Amount of Water.
Northern outlines of mallee at Koonamore	36·0%
Limit of mallee and arid formation at Dilkera	38·0%
Pure saltbush soils at Koonamore	38·0%
Typical mallee soil at Pinnaroo	36·0%
Typical mallee soil at Minnipa, E.P.	37·0%
Blue bush *(Kochia sedifolia)* soil	32·0%

The following soil profiles are typical:—

		pH value.
Pinnaroo.—*Eucalyptus dumosa*		
Medium red sand	12 inches	7·9
Buff coloured subsoil with limestone nodules		8·3
Koonamore.—*E. oleosa.*		
1. *Johnston's Paddock.*		
Surface soil, chocolate brown with humus	2 inches	7·4
Dark grey	8-9 inches	7·6
Subsoil		7·8
2. Mustering Paddock.—*E. oleosa.*		
Coarse red sand	2 feet	7·7
Subsoil, buff-coloured with limestone nodules		7·9
Cape Jervis.—*E. leptophylla.*		
Chocolate brown with humus		7·5
Subsoil, light brown with limestone		7·7
Minnipa.		
Brown sand with humus		7·5
Subsoil		7·9
Dilkera.		
Buff-coloured sand		7·7
Subsoil		8·0

These soils do not differ markedly from the more arid soils of the saltbush and bluebush formations. Two typical examples are:—

Koonamore.—*Atriplex vesicarium.*		
1. *Alderman's Paddock.*		
Brown sand and silt	2-3 inches	7·5
Subsoil, light grey-green with limestone		7·7
2. *St. Patrick's Paddock.*		
Brown sand and silt		7·6
Subsoil, grey-green with limestone		7·8

These examples, from all the chief mallee regions, show that the alkalinity of the soils is high, and particularly that of the subsoil in which the roots of the mallee ramify. This appears to be usually equal to about 8·0. Prescott (6) has found a pH of 9·6 in subsoils from Renmark and Coomealla. He states that on the alkaline side, calcium carbonate in equilibrium with the carbon dioxide of the atmosphere has a reaction pH 8·4, and that the high alkalinity of the subsoils is associated with partial replacement of the calcium of the soil with sodium of "alkali" salts by base exchange. The reaction is strikingly different from those of the Savannah Forest. Soils from Mount Pleasant, for example, showed a range of pH from 5·4 to 6·5, that is, the forest type is developed upon acid soils (5).

VEGETATION.

A. Floristics.

A complete list of about 600 species of plants found in the mallee is given in the Appendix. Different columns show the range of the various plant species. The columns are:—Murray Mallee, Yorke Peninsula, Eyre Peninsula, Southern and Northern Regions. The Southern Region comprises the land with a rainfall greater than 20 inches (this comprises the Mount Lofty Ranges) in South Australia and south-western Victoria, and the Northern Region land with a rainfall of less than 8 inches, comprising the great Northern Plains. Both these are beyond the limits of the mallee, but it will be seen that both of them merge into the mallee region.

The uniformity in habit of the chief tree species of the mallee scrub has obscured the true nature of this formation. It has been regarded as a formation comparable to the Eucalyptus forests of the Mount Lofty Ranges, so ably dealt with by Adamson and Osborn, or the communities of the arid flora. Analysis of the flora of the mallee, however, shows that it is a great transition region containing elements of both the Southern and the Northern Regions, and with but few endemic species. The different species of Eucalyptus which make up the mallee are co-climatic species in a great transition region, but the chief shrubs and undershrubs belong to other communities. It might be well to revive the old terms of Tate (10) and designate the Northern Flora the Eremian Flora, and the Southern Flora the Euronotian Flora, with its chief centre of distribution in South Australia in the Mount Lofty Ranges. The dividing line between the two is the 12-inch rainfall isohyet.

The area occupied by the mallee is a stable one geologically, and apparently floristically as well. Few communities can be recognised in it, and these are usually conditioned by slight edaphic differences and seldom occupy any considerable area.

The following Table 1 gives the analysis of the total mallee flora in South Australia:—

Table 1.

Total number of species	590	—
Number common with Southern Region ..	194	35%
Number common with Northern Region ..	204	35%
Wides (shared with North and South) ..	27	4·5%
Total number of species shared	425	74·5%
Number confined to region	165	25·5%

From this table it is evident that of the total number of species found only 25·5% are confined to the region, and that the great majority are plants from other regions. Of these confined plants the chief families and genera are:—

Acacia	17	species	}	Leguminoseae—32 spp.
Papilionatae	15	"	}	
Compositae	19	"		
Eucalyptus	9	"	}	Myrtaceae—18 spp.
Other Myrtaceae	9	"	}	
Chenopodiaceae	12	"		
Proteaceae	7	"		
Sapindaceae	7	"		
Goodeniaceae	7	"		

The migrants from the Southern Region are chiefly members of the Savannah Forest (2).

Further insight into the composition of the mallee flora can be gained by treating separately the three great territorial elements—the Murray Mallee, Yorke Peninsula and Eyre Peninsula.

1. The Murray Mallee.

The analysis of this region is given in Table 2:—

Table 2.

Total number of species	490	—
Number common with Southern Region	152	32%
Number common with Northern Region	183	37%
Wides	22	4·5%
Total number of species shared	357	73·5%
Number confined to Region	133	26·5%

In this region the number of species found is greater than in either of the other two, and of these the greater number is shared with the North. Of those confined to the region 28, or 6%, are endemic, that is to say, not shared with Yorke Peninsula or Eyre Peninsula. These plants are:—*Lamarkia aurea, Codonocarpus pyramidalis, Scleranthus miniscu1us, Lepidium monoplocoides, L. dubium, Acacia rhetinocarpa, A. montana, A. Bynoeana, A. Menzellii, Pultenaea prostrata, Dillwynia uncinata, Beyera opaca, Dodonaea cuneata, Spyridium subochreatum, Cryptandra amara, Pimelea Williamsoni, Callistemon brachyandrus, Eucalyptus incrassata, Micromyrtus ciliata, Halorrhagis ciliata, Eremophila divaricata, Velleia connata, Dampiera marifolius, D. rosmarinifolius, Olearia Hookeri, Cassinia aculeata, Humea pholidota, Calocephalus Sonderi.*

2. Yorke Peninsula.

Table 3 shows the analysis of the flora of this region.

Table 3.

Total number of species	302	—
Number common with Southern Region	142	47%
Number common with Northern Region	72	24%
Wides	24	8%
Total number of species shared	238	79%
Number confined to region	64	21%

Endemic species (not found in the Murray Lands nor on Eyre Peninsula) are as follows:—*Prasophyllum fuscoviride, Hibbertia Billardieri, Phebalium glandulosum, Veronica plebeja, Eucalyptus Behriana, E. Flocktoniae.*

Shared with Eyre Peninsula, but not found in the Murray Lands, are:—*Grevillea aspera, Didymotheca thesiodes, Acacia acinacea, Daviesia genistifolia, Phyllanthus calcynus, Lasiopetalum discolor, Thryptomene Miqueliana, Leucopogon Woodsii, Scaevola humilis, Olearia exiguifolia,* and *Angianthus phyllocalymmeus.*

Compared with the Murray region, the outstanding feature of the region is the large number (47%) of plants shared with the Southern Region and the small number shared with the North. This is to be expected when its geographical position is considered.

3. Eyre Peninsula.

The analysis of the flora of this region follows in Table 4.

Table 4.

Total number of species	406	—
Number common with Southern Region ..	150	36%
Number common with Northern Region ..	100	25%
Wides	23	5·5%
Total number of species shared	273	76·5%
Number confined to the region	133	23·5%

Endemic species are:—*Eragrostis trichophylla, Poa Drummondii, Triodia lanata, Loxocarya fasciculata,*ˣ *Caladenia toxochila, Hakea cycloptera, Chenopodium triangulare, Hemichroa diandra, Calandrinia brevipedata,*ˣ *Hutchinsia Drummondii, Acacia gonophylla,*ˣ *A. Merrallii,*ˣ *A. cyclopis,*ˣ *Bossiaea Walkeri,*ˣ *Templetonia Battii, Gastrolobium elachistum, Dicrastylis verticillata, Solanum hystrix,*ˣ *Anthocercis anisantha,*ˣ *Eremophila parviflora,*ˣ *Helipterum Humboldtianum,*ˣ *H. Haigii,*ˣ *H. tenellum,*ˣ *Humea assiniifolius.*

This region shows migrants from another flora, for of these endemics those marked with an asterisk, 11 in number are West Australian species.

Compared with the Murray Mallee, this region is characterised by the relatively small number of species shared with the North. This is the same as the number of Yorke Peninsula species shared with the North. This gives a basis for the fact noted by Prescott, namely, that the division between mallee and mulga country is sharper than the division between mallee and saltbush. The saltbush communities are typical of the north-east of South Australia and the mulga communities of the west of South Australia.

The southern limit of saltbush is shown on Prescott's vegetation map (4). This limit was compiled from survey data, but it follows closely the 12-inch isohyet. This line has a certain historical interest. In 1865, consequent on the great drought culminating in that year, the Surveyor-General of South Australia (G. W. Goyder) was ordered to "determine and lay down on the map, as nearly as practicable, the line of demarkation between that portion of the country where rainfall has extended and that where the drought prevails."

Goyder reported that the "line of demarkation extends from Swan Reach and then in a north-westerly direction to Burra Hill, then to Ulooloo and Mount Sly, and in a north-westerly direction by Tarcowie and Mount Remarkable, thence south by Ferguson's Range to the Broughton, and south-west to the east shore of Spencer Gulf to Franklin Harbour, and then north west to the west of the Gawler Ranges." This is approximately the 12-inch isohyet, and is the boundary between the Northern and Southern Regions.

B. Analysis of the Growth Forms.

In Table 5 an analysis of the life forms as defined by Raunkier is given. These are given as percentages. In the first horizontal column are given the usual symbols for the life form class. These are:—

Phanaerophytes: plants with dominant buds exposed freely to the air.

- MM *Mesophanaerophytes,* trees; 8-30 metres.
- M *Microphanaerophytes,* small trees and shrubs; 2-8 metres.
- N *Nanophanaerophytes,* shrubs; 2 metres and less.

Chamaephytes Ch: buds perennating on surface of ground or just above it (25 cm.).
Hemicryptophytes H: dormant buds in upper soil.
Geophytes G: dominant parts well buried.
Therophytes Th: ephemeral plants—annual plants with short life cycle.
Epiphytes E: These, in South Australia, are parasitic plants.

Table 5.

	MM.	M.	N.	Ch.	H.	G.	Th.	E.
Normal	6	17	20	9	27	3	13	3
Mallee	—	13	**30**	**19**	11	3·5	**21**	—
Murray Mallee	—	13	**31**	**19**	12	2·5	**21**	1·5
Yorke Peninsula	—	13	**32**	**15**	9	6·5	**22**	1·5
Mallee (indigenous) ..	—	**21**	**40**	**16**	8	1	14	—
Savannah forest (2) ..	1	8	14	12	26	23	14	1·5
Stringybark forest (2) ..	1	9	**34**	**13**	23	13	4	1
Ooldea (1)	—	19	**23**	**14**	4	0·5	**35**	4

The spectrum for the total mallee region is given, also that for the mallee of the Murray Mallee and for Yorke Peninsula. For comparison, the Normal or "World Spectrum" is given, also that for the forests of the Mount Lofty Ranges and that for the arid communities at Ooldea.

The outstanding feature of the mallee spectrum, as compared with the normal, is the high percentage of small woody plants Nanophanaerophytes and of ephemeral plants or Therophytes. It is a sclerophyll formation with a marked ephemeral element. Compared with the spectra for the savannah forest and Ooldea, it is seen that the mallee is intermediate between the two. The decrease in the number of geophytes characteristic of the savannah is marked, whilst the increase in the therophytic flora is striking but is not as high as that of Ooldea.

Comparing the spectra for the Murray Mallee and for Yorke Peninsula with its large percentage of southern forms, the most marked difference is in the percentages of geophytes which are relatively high under the higher rainfall of Yorke Peninsula.

An analysis is also given of the plants indigenous to the mallee. This is interesting, as it shows clearly the importance of the shrubs and woody undershrubs which together make up 76% of the plants characterising the region. The percentage of therophytes for these indigenous plants is the same as that of the savannah forest, and the high percentage for the total mallee shows that this is largely due to the northern forms—chiefly species of Compositae and Cruciferae.

C. Details of Ecology of various Mallee Communities.

In this section are given more detailed studies of certain mallee formations. The occurrence of communities within the mallee is rare. The ubiquitous "mallee" forms the top stratum of vegetation over the whole of the areas considered. It is replaced locally by "pine" (Callitris, spp.) *Casuarina lepidophloia*, or occasionally by other shrubs.

1. Scrub on Plains adjoining Mount Lofty Ranges.

A. *Eastern Scarp.*

Palmer lies at the foot of the Eastern Scarp of the Mount Lofty Ranges, and the division between the mallee of the plains and the savannah forests of the rolling hills is fairly sharp. On the hills themselves, and particularly highly developed

around Mount Pleasant, is a savannah forest of *Eucalyptus leucoxylon*. The constitution of this forest type has been dealt with by Adamson and Osborn (2). On approaching the scarp face, *Eucalyptus leucoxylon* is replaced by *Casuarina stricta* on the hill-tops, and on the lower slopes are the remains of once extensive belts of *Callitris robusta*. The continuation of such savannah forest shrubs as *Olearia tubuliflora, Dodonaea viscosa, Bursaria spinosa, Hibbertia sericea* is noticeable, and in particular the more xerophytic plants associated with *E. leucoxylon, H. ulicina,* and many composites characteristic of the savannah forest.

B. *Western Scarp.*

The eastern scarp of the ranges is clothed largely with a savannah forest of *Eucalyptus odorata*. *E. odorata* is a more xerophytic tree than is *E. leucoxylon,* although they share many plants in common, especially in the geophytic flora. In the northern portions of the ranges, and on the drier narrow coastal plains in the south, *E. odorata* invades the plains, and at its drier limits assumes a mallee habit until it merges into the mallee scrub proper of the plains dominated by *E. oleasa* and *E. dumosa.*

2. Scrub on Kangaroo Island and the Fleurieu Peninsula.

Kangaroo Island contains considerable quantities of mallee scrub. This is confined chiefly to the coastal plains of Recent origin and containing nodular travertine limestone. The character tree is a mallee, *Eucalyptus cneorifolia,* which is endemic to the island except for a small patch recorded on the Fleurieu Peninsula on the mainland adjoining the island. The area is all within the 20-inch isohyet. The scrub has a somewhat different facies from the bulk of the mallee on the mainland. Large shrubs are absent, but woody undershrubs, particularly those with a heathlike habit, are prevalent. The common associated species are:—*Melaleuca decussata, Orthrosanthrus multiflorus, Calythrix tetragona, Scaevola aemule, S. linearis, Pimelia phyllicoides, Hibbertia Billardieri, Leucopogon concinna, Clematis microphylla.* On the central tablelands of the island, mallee is replaced by the *Eucalyptus cosmophylla* scrub, characteristic of ironstone tablelands with a higher rainfall (see Adamson and Osborn).

At the tip of the Fleurieu Peninsula, at Cape Jervis, with a rainfall of 20 inches, there occurs a small patch of mallee scrub with the more localized species *Eucalyptus leptophylla* as the dominant tree. The species is closely allied to *E. cneorifolia* and easily mistaken for it. In this instance it forms a practically pure community on a chocolate-coloured soil (pH – 7·5) with an underlying brown soil containing travertine limestone nodules. The only plants found associated with it were *Clematis microphylla, Xanthorrhoea Tateana, Oxalis corniculata, Cheilanthes tenuifolia, Daviesia ulicina, Goodenia hispidula* and *Olearia tubuliflora*. It is replaced on the foothills by *Eucalyptus leucoxylon* savannah forest.

3. Scrub at Coomealla, N.S.W., near Mildura.

This area is near the northern limit of the mallee and contains almost entirely elements from the northern flora. This area is characteristic of large portions of the Murray lands north and south of the River Murray, including the Millewa district of Victoria and the Pinnaroo district of South Australia. Over considerable portions of this country sandhills occur, running chiefly east and west. These dunes are stable and are covered with vegetation. In this area communities within the mallee can be distinguished. As might be expected in these comparatively level plains with little difference in rainfall, edaphic difference becomes important in determining the distribution of communities of species.

In the Coomealla area four definite communities can be distinguished:—

Mallee proper.
Pine *(Callitris robusta)* communities.
Needlebush *(Hakea leucoptera)* communities.
Oak *(Casuarina lepidophloia)* communities.

The mallee is found on the usual soil type—a shallow surface soil, below this powdery limestone and nodular travertine to a depth of about 2-3 feet. *Eucalyptus dumosa* and *E. oleosa* occur mixed together, and it is impossible to distinguish any factors limiting their distribution. *E. oleosa*, if anything, appears in drier soils, and this is substantiated by the fact that it alone occurs in the outlying mallee at Koonamore in the north-east of South Australia. Associated with the mallee at Coomealla are found *Pittosporum phyllaroides, Heterodendron olaeifolium, Exocarpus aphylla,* and *Myoporum platycarpum*—all elements of the Northern Flora.

Callitris robusta frequently replaces the mallee. It grows on a soil with a deeper surface soil than mallee; below it becomes heavier and contains lime, but no nodular travertine. The deeper sand mulch indicates a moister soil than is typical for the mallee, and its occurrence on the lower slopes of the Mount Lofty Ranges points to this also. It is frequently associated with *Hakea leucoptera,* which sometimes forms an almost pure community in the mallee area. Other associated plants are *Acacia Oswaldii, Grevillea Huegelii,* and *Pimelia microcephala.*

In open patches of the pine community, and also in similar open patches in the mallee, therophyte communities consisting largely of *Hordeum murinum, Festuca bromoides, Stipa scabra, Gnaphalodes condensatum, Erodium cygnorum,* and *Goodenia glauca.*

The delicate balance which prevails, determining the occurrence of mallee or pine, in this region is shown in the dune areas. It is noticeable throughout the mallee along the River Murray between Renmark and Mildura that mallee occupies the north-facing drier slopes of the dunes, whilst pine occupies the south-facing slopes.

"Oak" or *Casuarina lepidophloia* is another common tree within the mallee area and is characteristic of a very definite soil type, a type which differs from those found in any other mallee communities. The surface soil contains a certain amount of lime, but below this, from about 2 feet downwards, the soil becomes heavy a clay, in fact—and contains little lime.

This survey at Coomealla is important, as it brings out clearly the marked change in vegetation which slight differences in soil profile produce.

4. Outliers of Mallee at Koonamore.

In the North-East of South Australia a few outliers of the main mallee area occur. The vegetation of the North-East is the characteristic saltbush one. Mallee follows the lower ridge of spurs of the Flinders Range towards Broken Hill and stops just beyond Olary. It is never found on the plains north of this, except where hills arise. One noticeable area is in Johnston's Paddock at Koonamore. Here it follows the lower ridges of the hills on a soil the profile and reaction of which is given on a previous page.

The mallee is *Eucalyptus oleosa* which here assumes a more "whipstick" form, and the leaves are an olive grey-green in colour—much greyer than the typical *E. oleosa* of the mallee proper. With it are associated *Atriplex stipitatum, A. vesicarium, Myporum platycarpum, Acacia rigens, Ermophila scoparia, Fusanus acuminatus, Templetonia egena, Lycium australe, Rhagodia spinescens, Salsoli Kali, Exocarpus aphylla, Heterodendron olacifolium,* and *Loranthus exocarpi* (or *Eremophila)* and *L. miraculosus* (or *Myoporum platycarpum).* All these are plants of the Northern Flora. The occurrence of the saltbush, *Atriplex stipitatum,*

with mallee is important, particularly in determining the range of this species. It is invariably found with mallee, replacing the commoner *A. vesicarium.* This fact is apparent to the sheep men of the country who always describe "mallee saltbush" as "poor bush," that is without the fodder value of *A. vesicarium.*

Mallee occurs also near the Vegetation Reserve of the University of Adelaide at Koonamore, on a soil which differs from Johnston's in that a deeper surface soil covers the underlying limestone soil. Practically the same plants are found associated with it as in Johnston's, but in addition *Olearia pimelioides, Acacia Burkettii, Stipa scraba,* and *Pittosporum phyllacroides.* Both these mallee communities are on less dry soils than those of the surrounding saltbush and bluebush communities. The difference lies in the greater depth of the surface soil, which frequently contains humus and acts as a more effective mulch which conserves the moisture in the subsoil. The profiles of the different communities are given on page 362.

Summary.

The mallee is a transition region between the savannah forests of the southern wetter districts and the Eremian or northern communities of saltbush and mulga.

The geographical range of the chief tree species *(Eucalyptus,* spp.) is sharply limited by the 20-inch isohyet in the south and the 8-inch isohyet in the north. In New South Wales its northern limit is determined by the northern limit of winter rains. The soils are all alkaline with a reaction of pH about 8·0, and all contain nodular travertine limestone.

Analysis of the growth forms gives a spectrum showing preponderance of woody shrubs and undershrubs of pronounced sclerophyll type and with a large therophytic element.

Analysis of the species shows that of the total number of species only about 25% are confined to the mallee, whilst the rest are migrants from the northern and southern communities. More detailed ecological studies of several mallee formations, showing its relation to other communities, are given.

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Appendix.

List of Species.

In this appendix is given a list of species occurring in the mallee regions. This list is compiled from the sources mentioned in the text of the paper, and is as complete as is possible at the present juncture. The list also gives the occurrence of the different species in the three mallee areas considered, and also in the Southern and Northern Regions. The following abbreviations have been used:—Y, Yorke Peninsula; M, Murray Mallee; E, Eyre Peninsula; S, Southern Region; N, Northern Region.

The nomenclature throughout is that of Black's "Flora of South Australia."

	Growth Form.	Y	M	E	S	N
Callitris glauca	M		x	x		x
C. robusta	M		x		x	x
C. propinqua	M	x	x	x	x	
C. Drummondii	M			x		
C. verrucosa	M	x	x	x		
Themeda triandra	Ch	x	x	x	x	
Tragus racemosus	H		x			x
Neurachne Mitchelliana	H		x		x	x
Panicum gracile	H		x		x	
Setaria viridis	H		x		x	
Phalaris minor	H		x		x	
Aristida arenaria	H		x		x	
A. Behriana	H		x		x	
Agropyrum scabrum	H	x			x	
Stipa elegantissima	H	x	x	x	x	
S. setacea, var. *latiglumis*	H			x	x	
S. acrociliata	H		x		x	
S. horrifolia	H		x	x		
A. semibarbata	H			x	x	
S. scabra	H	x	x	x	x	
S. pubescens	H		x	x	x	
Danthonia penicillata	H	x	x	x	x	
Triodia irritans	Ch		x			x
T. lanata	Ch			x		
Neurachne alopecuroides	H	x	x	x	x	
Lamarkia aurea	H		x			
Koelaria Michelii	H		x		x	
Eragrostis pilosa	H		x			x
E. trichophylla	H			x		x
E. major	H		x			x
E. eriopoda	H		x			
E. falcata	H		x			x
E. Dielsii	H		x			x
Poa Drummondiana	H			x		
P. bulbosa	H		x	x		
P. lepida	H	x	x			
P. caespitosa	H	x	x		x	
Chloris acicularis	H		x		x	
Cyperus difformis	H		x		x	
Lepidosperma laterale	Ch		x		x	
Loxocarya fasciculata	Ch			x		
Centrolepis polygyna	Th		x	x		
C. aristata	Th	x		x	x	
Burchardia umbellata	G			x	x	
Lomandra dura	Ch	x	x	x	x	
L. effusa	Ch		x	x	x	
L. micrantha	Ch			x	x	
L. glauca	Ch		x	x		
L. juncea	Ch			x	x	
Anguillarea dioica	G	x		x	x	
Thysanotus Patersonii	G	x	x	x	x	
T. Baueri	G	x		x	x	
T. dichotomous	G	x		x	x	
T. tuberosus	G			x	x	
Bulbine bulbosa	G	x	x	x	x	
B. semibarbata	G	x	x	x	x	
Arthropodium minus	G	x		x	x	
Hypoxis pusilla	G		x	x		
Prasophyllum occidentale	G			x	x	
P. patens	G	x		x	x	
P. elatum	G	x	x	x	x	
P. fuscoviride	G	x				
P. ordoratum	G	x	x	x	x	
Lyperanthus nigricans	G	x		x	x	

	Growth Form.	Y	M	E	S	N
Caladenia toxochila	G			x		
C. Patersonii	G	x	x	x	x	
C. filamentosa	G	x	x	x	x	
C. latifolia	G	x		x	x	
C. deformis	G	x	x	x	x	
Diuris pedunculata	G		x		x	
D. palustris	G	x	x		x	
D. maculata	G		x		x	
Casuarina stricta	M	x	x	x	x	
Casuarina lepidophloia	M		x			x
C. Muelleriana	M		x	x	x	
C. pusilla	M		x	x	x	
Parietaria debilis	T	x	x	x	x	x
Conospermum patens	M		x	x	x	
Hakea Baxteri	N			x		
H. leucoptera	M	x	x			x
H. cycloptera	M			x		
H. ulicina, var. *flexilis*	N		x	x	x	
Grevillea Huegelii	N	x	x	x		
G. ilicifolia	N	x	x	x		
G. pterosperma	N		x			x
G. aspera	N	x		x		
G. lavandulacea	N	x	x		x	
Exocarpus spartea	M	x	x			x
E. aphylla	M	x	x	x		x
E. stricta	M	x	x			
Leptomeria aphylla	N	x	x	x		
Choretrum glomeratum	N	x	x	x	x	
C. spicatum	N	x			x	
Fusanus acuminatus	M	x	x	x		x
F. persicarius	M	x	x	x		x
Loranthus exocarpi	E	x	x	x	x	x
L. Preissii	E	x	x	x	x	x
L. gibberulus	E		x			x
L. Miquelii	E	x	x	x	x	
L. miraculosus	E	x	x	x	x	x
Polygonium plebejum	T		x		x	
Muchlenbeckia adpressa	N	x	x	x	x	
M. Cunninghamii	N	x	x	x		x
M. diclina	N		x			x
Rhagodia parabolica	N		x	x		
R. Gaudichaudiana	N		x			x
R. spinescens	N		x			x
R. crassifolia	N	x	x	x		
R. nutans	N	x	x	x		
Chenopodium carinatum	N	x	x	x	x	
C. cristatum	N		x			x
C. microphyllum	N		x			x
C. desertorum	Ch		x			x
C. triangulare	Ch			x		x
Atriplex mummularium	N		x			x
A. stipitatum	Ch	x	x			x
A. angulatum	Ch		x			x
A. velutinellum	Ch		x	x		x
A. vesicarium	N		x	x		x
A. rhagodioides	N		x	x		x
A. semibaccatum	Ch	x	x	x	x	x
A. prostratum	Ch	x		x		x
A. Muelleri	Ch	x	x	x	x	x
A. campanulatum	Ch		x			x
A. leptocarpum	Ch		x			x
A. limbatum	Ch		x	x		x
A. halimoides	T		x	x		x
A. spongiosum	T		x	x		x
Bassia uniflora	Ch	x	x	x		x
B. sclerolaenoides	Ch		x	x		x

	Growth Form.	Y	M	E	S	N
B. parviflora	Ch		x	x		x
B. tricornis	Ch		x			x
B. stelligera	Ch		x			x
B. brachyptera	Ch		x			x
B. paradoxa	Ch		x			x
B. biflora	Ch		x	x		x
B. decurrens	Ch		x			x
B. tricuspis	Ch		x			x
B. longicuspis	Ch		x	x		x
B. divaricata	Ch		x			x
Kochia lobiflora	N			x		x
K. lanosa	N		x			x
K. brevifolia	N		x			x
K. pyramidata	N		x			x
K. tomentosa	N	x	x	x		x
K. sedifolia	N		x	x		x
K. Georgii	N		x	x		x
K. aphylla	N	x	x	x		x
K. excavata	N		x			x
K. triptera	N		x			x
K. ciliata	N		x			x
Salsola Kali	Th	x	x	x	x	x
Enchylaena tomentosa	N	x	x	x		x
Hemichroa pentandra	N	x	x		x	
H. diandra	N			x		
Trichinium exaltatum	Th		x	x		x
T. seminudum	Th		x	x		
T. alopecuroideum	Th	x	x	x		x
T. nobile	Th	x	x	x		x
T. spathulatum	Th	x	x	x		x
Alternanthera nodiflora	Th		x			x
A. denticulata	Th		x	x		x
Boerhavia diffusa	Th	x	x	x		x
Didymotheca thesioides	N	x		x		
Gyrostemon australasicus	M		x	x		x
Codonocarpus cotinifolius	M		x	x		x
C. pyramidalis	M		x			
Mesembryanthemum crystallinum ..	Ch	x	x	x	x	x
M. aequilaterale	Ch	x	x	x	x	x
M. australe	Ch	x	x	x	x	x
Tetragonia expansa	Th	x	x	x	x	x
Glinus lotoides	Th		x			x
G. spergula	Th		x			x
Calandrinia caulescens	Th		x			
C. volubilis	Th	x	x	x	x	
C. calyptrata	Th		x		x	
C. brevipidata	Th			x		
C. pygmaea	Th		x		x	
C. corrifioloides	Th	x	x	x		
Sagina procumbens	Ch		x	x		
A. apetala	Th	x	x	x	x	
Stellaria multiflora	H		x		x	
Minuartia tenuifolia	Th			x		
Spergularia rubra	H	x	x	x	x	
Drymaria filiformis	Th	x	x			
Gypsophila tubulosa	Th	x	x		x	
Silene nocturna	Th	x	x	x	x	
Scleranthus pungens	Ch			x	x	
S. minusculus	Th		x			
Herniaria hirsuta	Ch		x		x	
Clematis microphylla	H	x	x	x	x	
Ranunculus parviflorus	H	x	x	x	x	
Myosurus minimus	Ch		x	x		x
Cassytha pubescens	E	x	x	x	x	
C. melantha	E	x	x	x	x	
Papaver aculeatum	Th	x	x	x	x	

	Growth Form.	Y	M	E	S	N
Blennodia trisecta	N		x			x
B. nasturtioides	H		x			x
B. lasiocarpa	H	x	x			x
B. cardaminoides	H	x	x			x
Geococcus pusillus	H		x			x
Alyssum linifolium	Th	x	x	x		x
Lepidium leptopetalum	Ch		x			x
L. rotundum	Th	x	x	x		x
L monoplocoides	Th		x			
L. papillosum	Th		x	x		x
L. foliosum	Ch	x		x		
L. hyssopifolium	H		x		x	
L. dubium	Th		x			
L. fasciculatum	Th		x			x
Capsella pilosula	Th		x	x		
Hutchinsia Drummondii	Th			x		
H. eremea	H		x			
Stenopetalum lineare	Th	x	x	x	x	x
S. sphaerocarpum	Th			x	x	
Drosera Planchonii	G	x	x	x	x	
Crassula colorata	Th	x	x	x	x	x
C. Sieberiana	Th	x	x	x	x	
Pittosporum phyllaeroides	M	x	x	x	x	x
Bursaria spinosa	M	x	x	x	x	x
Cheiranthera linearis	N		x	x	x	
Billardiera cymosa	N		x	x	x	
Acacia continua	M		x	x		
A. acinacea	M	x		x		
A. obliqua	M	x	x	x		
A. rhetinocarpa	M		x			
A. erinacea	M			x		
A. microcarpa	M	x	x	x		
A. spinescens	M		x	x	x	
A. montana	M		x			
A. brachybotrya	M	x	x			x
A. Spilleriana	M		x	x		
A. anceps	M	x	x			
A. Victoriae	M		x			x
A. hakeoides	M	x	x	x		x
A. pycnantha	M	x	x	x	x	
A. notablis	M	x		x	x	
A. calamifolia	M		x	x		
A. aonophylla	M			x		
A. Bynoeana	M		x			
A. Merrallii	M			x		
A. cyclopis	M			x		
A. stenophylla	M		x			x
A. farinosa	M		x	x		
A. sclerophylla	M	x	x	x		
A. Oswaldii	M	x	x	x		x
A. rigens	M	x	x	x		x
A. Menzelii	M		x			
A. colletioides	M	x	x	x		x
Cassia Sturtii	N	x	x	x		x
C. eremophila	N	x	x	x		x
C. artemisioides	N	x		x		x
Daviesia ulicina	N		x		x	
D. incrassata	N		x	x		
D. genistifolia	N	x		x		
D. brevifolia	N	x		x	x	
Eutaxia microphylla	N		x	x	x	
Gastrolobium elachistum	N			x		
Pultenaea penduncluata	N		x	x	x	
P. prostrata	N		x			
P. largiflorens	N		x		x	
P. densifolia	N		x	x		

	Growth Form.	Y	M	E	S	N
P. tenuifolia	N		x	x		
Aotus villosa	N		x	x		
Dillywinia hispida	N		x	x	x	
D. uncinata	N		x			
Bossiaea Walkeri	N			x		
Templetonia retusa	M			x	x	
T. egena	M		x	x		x
T. Battii	M			x		
T. sulcata	N	x	x			
Goodia lotifolia	N	x		x	x	
Lotus australis	H	x	x	x	x	x
Psoralea eriantha	Ch		x			x
Swainsonia procumbens	Ch		x			x
S. lessertifolia	N		x	x		
S. oroboides	H		x		x	
S. reticulata	H		x	x		
S. microphylla	H		x			x
S. laxa	H	x	x			
S. stipularis	H		x			x
S. phacoides	H	x	x			x
Kennedya prostrata	H	x			x	
Hardenbergia monophylla	N	x	x		x	
Glycine clandestine	H	x	x	x	x	
Geranium pilosum	H		x	x		x
Erodium cygnorum	Th	x	x	x	x	x
Zygophyllum apiculatum	N	x	x	x		x
Z. Billardieri	Th	x	x	x		x
Z. glaucescens	Th	x	x	x		x
Z. crenatum	Th	x	x	x		x
U. ovatum	Th	x	x	x		x
Z. fruiticulosum	N	x	x	x		x
Boronia caerulescens	N		x	x	x	
B. inornata	Ch	x	x	x		
Correa rubra	N	x	x	x	x	
Phebalium pungens	N		x	x		
P. glandulosum	N	x				
P. bullatum	N		x			
Microcybe pauciflora	N	x	x	x		
M. multiflora	N		x	x		
Geijera linearifolia	N		x			x
Comesperma Scoparium	N		x	x		
Phyllanthus calycinus	M	x		x		
P. lacunarius	Th		x	x		
P. Fuernrohrii	N		x			x
Adriana Klotzschii	M	x	x	x	x	
Euphorbia australis	Th		x			x
E. eremophila	Th		x	x		x
Poranthera microphylla	Th		x		x	
P. triandra	Th		x	x		
Beyeria opaca	N		x			
B. Leschenaultii	N	x	x	x		
Bertya Mitchellii	N	x	x			
Stackhousia mongyna	Ch	x	x	x	x	
Heterodendron olaeifolium	M	x	x	x		x
Dodonaea viscosa	N	x	x	x	x	
D. attenuata	N		x			x
D. cuneata	N		x			
D. Baueri	N	x	x	x		
D. bursariifolia	N	x	x	x		
D. hexandra	N	x	x	x		
D. lobulata	N	x	x	x		
D. stenozyga	N	x	x	x		
D. humilis	N	x	x	x		
Pomaderis racemosa	N	x	x	x		x
P. obcordata	N	x		x	x	
Spyridium phylicoides	N	x	x	x	x	

	Growth Form.	Y	M	E	S	N
S. eriocephalum	N		x		x	
S. subochreatum	N		x			
Cryptandra leucophracta	N	x	x	x		
C tomentosa	N	x	x	x	x	
C. amara	N		x			
C. propinqua	N			x		x
Lavatera plebeja	Th	x	x	x	x	
Plagianthus glomeratus	Ch	x	x	x	x	
P. Berthae	Ch	x	x			
Sida corrugata	Ch	x	x	x		x
S. intricata	Ch	x	x			x
S. virgata	Ch		x			x
S. petrophila	Ch	x	x	x		x
Abutilon Theophrasti	Ch		x			x
Hisbiscus Krichauffianus	N		x			x
H. Farragei	N		x			x
H. Huegelii	N	x	x	x		x
Lasiopetalum discolor	N	x		x		
L. Behrii	N	x	x	x	x	
L. Baueri	N	x	x	x	x	
L. Schulzanii	N	x		x		
Hibbertia sericea	N	x	x	x	x	
H. paeninsularis	N			x		
H. stricta	N	x	x	x	x	
H. Billardieri	N	x				
H. virgata	N	x	x		x	
Frankenia fruiticulosa	Ch	x	x	x		
Hybanthus floribundus	N		x	x	x	
Pimelea glauca	N	x	x	x	x	
P. microcephala	N		x	x	x	
P. flava	N		x	x	x	
Pimelea trichostachya	Ch		x	x		x
P. Williamsonii	Ch		x			
P. micrantha	Ch		x	x	x	
P. octophylla	N	x	x	x	x	
P. phylicoides	N	x	x		x	
P. ammocharis	Ch			x		x
Baeckea crassifolia	N	x	x	x	x	
B. ericaea	N	x	x			
B. Behrii	N		x	x		
Leptospermum coriaceum	N	x	x	x		
Callistemon rugulosus	N	x		x	x	
C. brachyandrus	N		x			
Melaleuca decussata	N	x		x	x	
M. acuminata	N	x	x	x		
M. pubescens	N	x	x	x	x	
M. uncinata	N	x	x	x		
M. pauperiflora	N	x	x	x		
Eucalyptus diversifolia	M	x	x	x		
E. Behriana	M	x				
E. odorata	M	x	x	x	x	
E. leptophylla	M	x	x	x	x	
E. oleosa	M	x	x	x		
E. Flocktoniae	M	x				
E. angulosa	M	x	x	x		
E. dumosa	M	x	x	x		
E. incrassata	M		x			
E. calycogona	M	x	x	x		
E. gracilis	N	x	x	x		
Micromyrtus ciliata	N		x			
Thryptomene Miqueliana	Ch	x		x		
Calythrix tetragona	N	x	x	x	x	
Londonia Behrii	Ch	x		x	x	
L. aurea	Ch			x		x
Halorrhagis teucrioides	H	x		x	x	
H. hetrophylla	H	x	x	x	x	

	Growth Form.	Y	M	E	S	N
H. mucronata	H		x		x	
H. ciliata	H		x			
H. acutangula	H	x	x	x	x	
H. odontocarpus	H		x	x	x	
Hydrocotyle medicaginoides	H	x	x	x		
H. callicarpa	Th	x		x	x	
H. capillaris	Th	x		x	x	
Didiscus pusillus	Th	x		x	x	
D. cyanopetalus	Th	x	x	x	x	
D. ornatus	Th			x		x
Bupleurum semicompositum	Th		x	x	x	
Styphelia exarrhena	N		x	x		
Astroloma conostephioides	N	x	x	x	x	
Lissanthe strigosa	N	x		x	x	
Leucopogon cordifolius	N	x	x	x	x	
L. rufus	N	x		x	x	
L. Woodsii	N	x		x		
Acrotriche cordata	N	x		x	x	
Brachyloma ericoides	N		x		x	
Jasminum lineare	N		x			x
Mitrasacme paradoxa	Ch	x		x	x	
Logania recurva	N	x		x		
L. ovata	N	x		x		
Sebaea ovata	Th	x	x	x	x	
Sarcostemma australe	N (s)	x	x	x		x
Cressa cretica	Ch		x			x
Halgania cyanea	Ch	x	x	x		
H. lavendulacea	Ch	x	x	x		
Heliotropum curassavicum	Ch		x	x		x
Lappula concava	Th	x	x	x		x
Eritrichium australasicum	Th	x	x	x		
Rochelia plurisepala	Ch		x	x		x
Dicrastylis verticillata	Ch			x		
Ajuga asutralis	H	x	x	x	x	
Teucrium racemosum	N	x	x	x		x
T. sessiliflorum	Ch	x	x	x		x
Prostranthera spinosa	N		x	x		x
P. aspalathoides	N		x		x	
P. microphylla	N	x	x	x		
Westringia rigida	N	x	x	x		x
W. angustifolia	N	x	x	x		
Solanum simile	N	x	x	x		
S. esuriale	Ch		x			x
S. hystrix	Ch			x		
Lycium australe	N	x	x	x		
Nicotiana suaveolens	Th	x	x	x	x	x
Duboisia Hopwoodii	N		x			x
Anthocercis anisantha	Ch			x		
A. myosotidea	Ch		x	x		
Morgania glabra	N	x	x	x	x	x
Veronica distans	Th	x	x	x	x	
V. plebeja	Ch	x				
Euphrasia collina	Ch	x	x	x	x	
Myoporum montanum	N		x			x
M. deserti	M	x	x	x		x
M. viscosum	M	x		x	x	
M. platycarpum	M	x	x	x		x
Eremophila oppositifolia	M		x			x
E. Sturtii	M		x			x
E. longifolia	M	x	x	x		x
E. divaricata	M		x			
E. crassifolia	M	x	x			
E. Weldii	M			x	x	
E. parviflora	M			x		
E. polyclada	M		x			x
E. Behriana	M	x	x	x		
E. maculata	M		x			x

	Growth Form.	Y	M	E	S	N
E. serrulata	M		x			x
E. scoparia	M	x	x	x		x
E. alternifolia	M		x	x		x
E. glabra	M	x	x	x		x
Opercularia varia	Ch	x			x	
Asperula scoparia	H		x		x	
A. conferta	H		x		x	
Galium Gaudichaudii	Ch	x	x	x	x	
G. umbrosum	Ch	x	x	x	x	
Wahlenbergia gracilis	Th	x	x	x	x	
Goodenia primulacea	H	x	x	x	x	
G. geniculata	H	x	x	x	x	x
G. affinis	H	x	x	x	x	
G. robusta	Ch	x	x	x		
G. varia	Ch	x	x	x		
G. pinnatifida	Th	x	x	x		x
G. pusilliflora	Th	x	x	x	x	
G. glauca	Ch		x			x
G. subintegra	Ch		x			x
Velleia paradoxa	Th	x	x	x		x
V. connata	Th		x			
Scaevola spinescens	H	x	x	x		x
S. aemula	H	x	x	x		
S. linearis	Ch	x		x		
Dampiera marifolia	Ch		x			
D. rosmarinifolia	Ch		x			
D. lanceolata	Ch		x	x		
Brachycome goniocarpa	Th		x	x		
B. pachyptera	Th		x	x		x
B neglecta	Th	x	x	x	x	
B. exilis	Th	x	x	x	x	
B. debilis	Th	x		x	x	
B. purpusilla	H	x	x	x	x	
Minuria leptophylla	Ch	x	x	x		x
M. Cunninghami	Ch	x	x	x		x
M. integerrima	Ch		x			x
M. suadifolia	Ch	x	x	x		x
Calotis aureifolia	Ch		x			x
C. cymbacantha	Th		x			x
C. erinacea	Th	x	x	x		x
C. hispidula	Th	x	x	x		x
Vittadinia triloba	Ch	x	x	x		x
V. megacephala	H		x	x		
Olearia pannosa	H	x	x	x	x	
O. ramulosa	N	x		x	x	
O subspicata	N	x				x
O. floribunda	N	x	x	x		x
O lepidophylla	N	x	x	x		
O. exiguifolia	N	x		x		
O. pimeleoides	N		x	x		x
O. magniflora	N		x	x		
O. Muelleri	Ch		x	x	x	
O. calcarea	Ch		x	x		
O. decurrens	Ch	x	x	x		
O. glutinosa	N		x		x	
O. teretefolia	N		x		x	
O. Hookeri	N		x			
O. picridifolia	N		x			x
Centipeda thespidioides	Ch		x			x
Elacanthus pusillus	Th	x	x	x	x	x
Erichthites picridifolia	Th	x	x	x		
E. quadridentata	Th	x	x	x	x	x
E. hispidula	H	x	x	x	x	x
Senecio brachyglossus	Th	x	x	x	x	
S. magnificus	N		x			x
S. odoratus	N	x	x	x	x	x
Cratystylis conocephala	N	x	x	x		x

	Growth Form.	Y	M	E	S	N
Epaltes Tatei	Th		x	x		x
E. australis	Th			x		x
Stuartina Muelleri	Th	x	x	x		x
Gnaphalium luteo-album	Th	x	x	x	x	x
G. indutum	Th	x	x	x		x
G. indicum	Th		x			x
Cassinia aculeata	N		x			
C. laevis	N		x			x
C. companata	N	x	x			x
C. arcuata	N	x	x		x	
Helipterum floribundum	Th	x	x			x
H. Sturtianum	Th	x	x	x		x
H. polygalifolium	Th		x	x		x
H. albicans	Th		x	x		x
H. variablile	Th	x		x	x	
H. Jessenii	Th	x	x	x	x	
H. pygmaeum	Th	x	x	x		x
H. Humboldtianum	Th			x		
H. Haigii	Th			x		
H. tenellum	Th			x		
H. corymbiflorum	Th	x	x	x	x	x
H. moschatum	Th		x			x
H. uniflorum	Th		x			x
H. Tietkensii	Th		x	x		x
H. laeve	Th		x	x		x
H. australe	Th	x	x		x	
Ixiolaena leptolepis	Ch		x			x
I. tomentosa	Ch	x	x	x		x
Helichyrsum obtusifolium	Ch	x	x	x	x	
H. Baxteri	Ch	x	x	x	x	
H. leucopsidium	Ch	x	x	x	x	
H. adenophorum	Ch			x	x	
H. scorpiodes	Ch	x	x		x	
H. apiculatum	Ch	x	x	x	x	x
H. semipapposum	Ch	x	x	x	x	x
H. Tepperi	Th	x	x	x	x	
H. retusum	N	x	x	x		
Leptorrhynchus squamatus	Ch		x			x
L. tetrachaetus	Ch	x	x	x	x	
L. medius	Th	x	x	x	x	
L. Waitzia	Th	x	x	x	x	
Waitzia acuminata	Th	x	x	x		x
Humea cassiniiformis	N			x		
H. pholidota	N		x			
Ixodia achilleoides	N	x	x	x	x	
Podolepis acuminata	Ch		x			x
P. canescens	Th		x	x		x
P. rugata	Ch	x	x	x	x	
P. capillaris	Th		x	x		x
Athrixia tenella	Th	x	x	x		x
Myriocephalus rhizocephalus	Th	x	x	x		
M. Stuartii	Th		x	x		x
Angianthus tomentosus	Th	x	x	x		x
A. brachypappus	Th		x			x
A. Phyllocalymmeus	Th	x		x		
A. strictus	Th	x	x	x	x	
A. pusillus	Th		x	x		x
Gnephosis skirrophora	Th		x	x		x
G. cyathopappa	Th		x			x
Eriochylamys Behrii	Th	x	x	x		x
Calocephalus Drummondii	Th	x	x	x	x	
C. Sonderi	Th		x			
Gnaphaloides ulinigosum	Th	x	x	x	x	
Craspedia uniflora	Ch	x	x	x	x	
C. pleiocephala	Th		x			x
Chthonocephalus pseudevax	Th		x	x		x
Microseris scapigera	G	x	x	x	x	

ABSTRACT OF THE PROCEEDINGS

OF THE

ROYAL SOCIETY OF SOUTH AUSTRALIA

(Incorporated)

FOR THE YEAR NOVEMBER 1, 1928, TO OCTOBER 31, 1929.

ORDINARY MEETING, NOVEMBER 8, 1928.

PROFESSOR HARVEY JOHNSTON was in the chair, and 32 members were present. Apologies were received from the President and Dr. Fenner.

The minutes of the previous meeting were read and confirmed.

NOMINATIONS.—James Davidson, D.Sc., Entomologist, Waite Institute, Adelaide; Eugene McLaughlin, M.B., B.S., M.R.C.P., Laboratory, Adelaide Hospital; Sidney Frederick Tee, Laboratory Assistant, Adelaide Hospital.

SIR JOSEPH VERCO MEDAL.—The following conditions were agreed to, and carried by the meeting (conditions 1, 2, 3 and 4 having been carried at the previous meeting) :—

5. That on the other side of the medal there be a surrounding wreath of eucalypt.
6. That the words "Awarded by the Royal Society of South Australia," the name of the recipient, and the year be engraved on each medal, within the eucalypt wreath.
7. That the Council select the person to whom it is suggested that the medal shall be awarded, and that the name shall be submitted to the Fellows at an Ordinary Meeting to confirm, or otherwise, the selection of the Council by ballot or otherwise.
8. That the medal be awarded for distinguished scientific work published by a member of the Royal Society of South Australia.

DEMONSTRATION.—Professor HAROLD DAVIES., Mus. Doc., gave a recital of records of Aboriginal songs taken during the Adelaide University Anthropological Expedition to Koonibba in August, 1928.

EXHIBITS.—Mr. EDWIN ASHBY, F.L.S., exhibited some chitons collected by Mr. W. J. Kimber in the Capricorn Group, Queensland, in 1927. Amongst them were two new species, one a most remarkable form with sculpture unsurpassed by any other species. Its nearest relative is known only from a single specimen from Darnley Island, Torres Strait, near Papua, and both these two unique examples are related to a species found in the Philippine Islands, *Chiton pulcherrimus.* The Capricorn shell differs chiefly from the example from Torres Strait in being ornamented with a coarse net-work sculpture, which is not shown in the figure of the type from Darnley Island. The other new species, which is being named after the finder, is a highly polished shell practically without sculpture; its true characters were only revealed on disarticulation. Also a number of specimens of *Tonicia shirleyi,* a genus of chiton not found in South Australian waters, delicately tesselated in colour patterns of shades of pink, tinged with green. This chiton is peculiar in having developed in the shell a series of sense organs resembling "eyes." He also showed amongst other forms collected by Mr. Kimber, in the

Capricorn Group, another form also possessing eyes and a girdle covering consisting of coarse calcareous spines. Mr. KIMBER gave an account of his experiences in collecting chitons on the Coral Reef of the Capricorn and Bunker Groups, and exhibited *Cymbium flammeum* from North West Island, Capricorn Group, with its egg nidus and fully-formed young shells. Professor HARVEY JOHNSTON showed a tapeworm from the emperor penguin which gives rise to a large number of cysts in the intestines of the bird; in these cysts the scolices are enclosed. Miss V. TAYLOR showed the egg nidus of a mollusc.

ORDINARY MEETING, APRIL 11, 1929.

THE PRESIDENT (Dr. L. Keith Ward) was in the chair, and 34 Fellows were present.

The Minutes of the previous meeting were read and confirmed.

SIR JOSEPH VERCO MEDAL.—THE PRESIDENT submitted for endorsement by the general meeting the name of Professor Walter Howchin, who had been chosen by the Council as the first recipient of the Sir Joseph Verco Medal. Dr. ROGERS moved that the recommendation of the Council be endorsed by the Society. He congratulated the Council on the association of names of Verco and Howchin, two mainstays of the Society for many years. Professor Howchin's association with the Society dates back to 1883. He has been President, Editor, and Governing Director, a great geologist, and an eminent author. Mr. HAM seconded the motion. Professor Sir EDGEWORTH DAVID said that he esteemed it a great privilege to add his appreciation to what had been said. He and Howchin started to collaborate in geology 35 years ago. Professor Howchin, in all that time, has been most generous in providing material, and even unpublished information. Dr. Gregory, of Glasgow, gives Howchin the credit for his discovery of evidence of early glaciation which has stood the test of time better than ony other. Dr. FENNER moved, and Professor HARVEY JOHNSTON seconded, that the selection be decided by a show of hands. Carried unanimously. THE PRESIDENT then put the original motion, which was carried by a show of hands. THE PRESIDENT, on behalf of the Council, expressed himself as being extremely gratified at the support of the meeting.

NOMINATION.—John Kingsley Taylor, Commonwealth Soil Survey Officer, Waite Agricultural Research Institute.

ELECTIONS.—James Davidson, D.Sc., Entomologist, Waite Agricultural Research Institute; Eugene McLaughlin, M.B., B.S., M.R.C.P., Laboratory, Adelaide Hospital; Sidney Frederick Tee, Laboratory Assistant, Adelaide Hospital, were unanimously elected as Fellows.

THE PRESIDENT drew attention to the new issue of Instructions to Authors.

Professor HARVEY JOHNSTON asked the meeting to join with him in congratulating Dr. Fenner in being awarded the David Syme prize and medal for research. Sir E. DAVID, in supporting, said that in N.S.W., Fenner's work on Physiography has filled them with admiration. THE PRESIDENT said that the Society, as a body, unanimously congratulated Dr. Fenner winning the prizes, and that this would be incorporated in the minutes.

THE PRESIDENT sought for confirmation of his action in electing Mr. Glastonbury as Auditor for the purpose of securing the Government Grant. Carried unanimously.

PAPERS—

1. "Further Notes on the Fossils of the Adelaide Series (Lipalian)," by Professor Sir EDGEWORTH DAVID, F.R.S. Illustrated by lantern slides.
2. "The Vegetation Map of South Australia," by Professor J. A. PRESCOTT, M.Sc.

3. "Geological Notes, Hundred of Adams, Flinders Ranges," by RALPH W. SEGNIT, M.A., B.Sc.
4. "The Australian Species of Cidarids, particularly of the Genus *Phyllacanthus* and their Distribution along the Coast of Australia," by TH. MORTENSEN, Copenhagen. Communicated by Prof. T. Harvey Johnston.
5. "Notes on the Larval Trombidiid Mite *(Trombicula hirsti* L. Sambon) causing the 'Scrub Itch' of North Queensland and the Coorong," by STANLEY HIRST.
6. "Some Fossil Remains from the Adelaide Series of South Australia," by F. CHAPMAN, A.L.S.

EXHIBITS.—Professor HARVEY JOHNSTON exhibited specimens of *Limulus*. Mr. MOUNTFORD, "Casts of Petroglyphs," including one very large one of a supposed crocodile's head from Bimbowie Creek.

ORDINARY MEETING, MAY 9, 1929.

THE PRESIDENT (Dr. L. Keith Ward) was in the chair, and 41 Fellows were present. Lady Verco was present as a visitor.

NOMINATIONS.—As Fellows: Bernard Charles Cotton, South Australian Museum; Frank Mitton Angel, Accountant, 34 Fullarton Road, Parkside; John Whinham Hosking, Dentist, 77 Sydenham Road, Norwood; and as Associate: William Paton Cleland, Science Student, University, Adelaide.

ELECTION.—John Kingsley Taylor, Commonwealth Soil Survey Officer, Waite Agricultural Research Institute, Glen Osmond. Unanimously elected a Fellow.

Professor PRESCOTT asked the Society to join him in congratulating the President (Dr. L. Keith Ward) on his appointment to the Coal Commission.

THE PRESIDENT thanked the Fellows for their congratulations.

PRESENTATION OF THE "SIR JOSEPH VERCO MEDAL."—THE PRESIDENT remarked that he was very glad that Sir Joseph was able to come in person to make the presentation to Professor Walter Howchin. A short address was given by THE PRESIDENT on the foundation and objects of the medal.

THE SIR JOSEPH VERCO MEDAL.

The Council, on August 23, 1928, having resolved to recommend to the Fellows of the Society that a medal should be founded to give honorary distinction for scientific research, and that it should be designated the Sir Joseph Verco Medal, was submitted to the Society at the evening meeting of October 11, 1928, and at a later meeting, held on November 8, 1928, when the recommendation of the Council was confirmed on the following terms:—

REGULATIONS.

XI.—"The medal shall be of bronze, and shall be known as the Sir Joseph Verco Medal, in recognition of the important service that gentleman has rendered to the Royal Society of South Australia. On the obverse side of the medal shall be these words: 'The Sir Joseph Verco Medal of the Royal Society of South Australia,' surrounding the modelled portrait of Sir Joseph Verco, while on the reverse side of the medal there shall be a surrounding wreath of eucalypt, with the words: 'Awarded to.. for Research in Science,' the name of the recipient, and the year of the award. The Council shall select the person to whom it is suggested that the medal shall be awarded, and that name shall be submitted to the Fellows at an Ordinary Meeting to confirm, or otherwise, the selection of the Council, by ballot or show of hands. The medal shall be awarded for distinguished scientific work published by a Member of the Royal Society of South Australia."

The First Award.

The Council having nominated Professor Walter Howchin, F.G.S., as the first recipient of the Sir Joseph Verco Medal, his name was submitted to an Ordinary Meeting of the Fellows of the Society on April 11, 1929, and the nomination was heartily confirmed.

The President, Dr. L. Keith Ward, having made the above Announcement, Addressed Professor Howchin in the following Terms:—

"Professor Walter Howchin.

"The Council of the Royal Society of South Australia, in nominating you as the first recipient of the Sir Joseph Verco Medal for scientific research, has found a unanimous acceptance of the nomination by the Fellows.

"In making this award, the Society is recognising only the value of your scientific researches. Your long connection with the Society, and the services that you have rendered to it in different capacities, cannot be forgotten, though they have not been the cause of your selection for this honour.

"During the 48 years of your residence in South Australia, you have been continuously active in the work of unravelling the geological history of the State. Many of your most important contributions have been published in our own Transactions; and the Society has been proud to print these records of your work in stratigraphy; physiography; structural geology; palaeontology; and, above all, in palaeoglaciology.

"This work, on which you are still engaged, has been of major importance in tracing the geological history of a large portion of South Australia; and much of it has been carried out under conditions that give proof of your unquenchable enthusiasm and determination.

"The Society, in according to you the greatest honour that lies in its power to bestow, trusts that you will long find health and strength to carry on the investigations with which your name is associated throughout the geological world."

Presentation made by Sir Joseph Verco.

"Mr. President and Fellows of the Royal Society.

"Let me apologise for my long absence from the meetings of the Society and its Council. This is my first evening function for nine months.

"May I first thank the Society for associating me with the medal it has struck. My 'image and superscription' will be an honour in perpetuity.

"I have also to thank our President (one of *whose* perquisites this should be) for calling upon *me* to make this first presentation.

"Let me inform you that this is not Professor Howchin's first experience of the kind, for he has already received the Clarke Memorial Medal, presented by the Royal Society of New South Wales.

"Dr. Ward has just given us, in bare outline, the scientific work for which Professor Howchin is deemed worthy of the present honour. And our own publications contain evidence of the large amount of scientific work he has done.

"We have no doubt, therefore, about the *propriety* of the first presentation of our medal to Professor Howchin for his research in Science.

"But other considerations make this presentation a pleasure as well as a propriety.

"For 46 years his name has been on our roll. Only two Fellows precede him, namely, Mr. George Goyder, 49 years; and myself, 51. And during all that period he has been a great asset to the Society in various ways. It is questionable whether any Fellow has been more regular, more punctual or more helpful than he.

"For several years he was our representative on the Board of Governors of the Public Library, Museum and Art Gallery, and for a very long period has acted as Editor of our Transactions, Proceedings and Reports, occupying this very difficult, onerous and delicate position with an enviable capacity, care and assiduity.

"And all this makes the presentation as pleasant as it is appropriate.

"Professor Howchin, on behalf of the Royal Society of South Australia, I present to you this medal for your research in Science, and heartily congratulate you as its first recipient."

In Reply.

Professor Howchin, after thanking the President and Sir Joseph Verco for their kindly references to his scientific accomplishments and association with the Royal Society of South Australia, said that the work in which he had been engaged had been a great pleasure to him. It was gratifying to know that it had received the Society's recognition, and he felt it a great honour to be chosen as the first recipient of the Society's medal. The pleasure he felt was greatly enhanced in that he had the privilege to receive the medal at the hands of Sir Joseph himself. The name with which the medal was associated was very dear to him. Sir Joseph Verco was not only the oldest member of the Society but is the only living representative of those who constituted the membership of the Society, in its earliest stage, when it was known as The Philosophical Society of Adelaide. Sir Joseph had enriched the Society by his wise counsels, administrative ability and valuable scientific communications, as well as by his financial support and influence. It was through Sir Joseph's generous example and personal influence that the endowment fund had been established which would be a guarantee towards meeting the costs, to a certain extent, of the Society's publications in perpetuity. The medal would stand for all time as a memorial of the great services he had rendered the Society. The Professor stated that this was the fourth medal he had been awarded for scientific research or service. Of all these he placed the highest value upon the one he had just received. It was an expression of confidence from his more immediate scientific associates and that kindly relationship that had existed for more than 40 years. When he joined the Society in 1883, it had had an existence for only six years, the meetings were held in an upper room of the old Institute Building; the attendances were small, and the library of the Society was contained in a cupboard with closed doors. The income of the Society was little over £200, including £90 as the Government Grant, and the cost of printing and publishing the Transactions of the Society was only £67. In contrast with this, last year's published balance-sheet showed printing and publishing costs amounting to £537, with a balance in hand. The Professor stated

that in 1884 he was elected a member of the Council, an office that he had filled ever since. In 1885 he was elected Vice-President and Editor. Professor Tate in that year, for personal reasons, resigned the editorship, which extended over a period of four years. During this interval, and two subsequent years, and on Professor Tate's death, in 1901, the editorship passed again into his (Professor Howchin's) hands, and has continued so to the present day, making a total of 34 years. The Royal Society (the Professor stated) had generously published 55 of his papers in the Transactions, and he still had a few more on hand which require some finishing touches before publication. He was very grateful for the uniform kindness he had received from the officers and members of the Society, and expressed the hope that his happy connection with the Society would be continued for many years yet.

PAPERS—

1. "Variations of the Hydrogen Ion Concentration in the Neighbourhood of the Estuary of the River Murray," by T. BRAILSFORD ROBERTSON. THE PRESIDENT said that Fellows should be thankful to Professor Robertson for introducing an important and interesting subject. Professor PRESCOTT said that the paper opened up a new field of work, and hoped that Zoologists and Botanists will follow the lead. Lakes at the mouth of the Murray are promising localities for ecological studies. Professor HARVEY JOHNSTON remarked on the Algae in the Coorong and their products of decomposition; also, that while mullet were abundant far up the Coorong, the mulloway was restricted to its opening near the Murray mouth. Mr. HALE remarked that estuarine forms in South Australia overlap a good deal on both sides, and that creatures like *Pseudaphritis* and fresh water crayfish are very adaptable.
2. "On the Probable Occurrence of Sturtian Tillite at Nairne and Mount Barker," by Professor WALTER HOWCHIN, F.G.S. Mr. R. LOCKHART JACK said the clue which led to the recognition of these deposits was a note "ice" on a manuscript map made by the late H. Y. L. Brown.
3. "Crustacea from Princess Charlotte Bay, North Queensland," by HERBERT M. HALE.
4. "Crustacea from Dirk Hartog Island, Western Australia," by HERBERT M. HALE.
5. "A New Xanthid Crab from South Australia," by Dr. MARY J. RATHBUN. (Communicated by H. M. Hale.)

EXHIBITS.—Professor PRESCOTT exhibited a Soil Survey Map of Block E at Renmark, with an Aerial Map of the same area. Mr. ARTHUR M. LEA exhibited larvae, eggs, and mature insects of the cactus moth, *Cactoblastic cactorurri*, which has been introduced into Queensland and New South Wales from South America, and doing an immense amount of good in destroying the prickly pear in the Eastern States. So far it does not seem to have been seriously attacked by any parasite in Australia, and if this state continues there is every prospect of its reducing the prickly pear to harmless proportions. Also specimens of the dried fruit moth, *Plodia interpruncteIla*, for many years one of the most serious pests attacking dried fruits and meals. Recently Mr. H. Showell (one of our Fellows) devised a treatment of dried fruits with a petrol extract that effectively protects them against attacks of the insects, without in any way rendering the fruit distasteful or unsightly, as evidenced by an exhibit of four samples of sultanas from the 1927 crop, that showed no signs whatever of the work of the dried fruit moth or other insects.

ORDINARY MEETING, JUNE 13, 1929.

Dr. CHARLES FENNER, Vice-President, was in the chair, and 29 members were present.

Dr. FENNER tendered an apology for the absence of the President, Dr. L. Keith Ward, who was out of the State in connection with the Coal Commission.

Minutes of the Ordinary Meeting, held on May 9, 1929, were read and confirmed.

ELECTIONS.—

1. Of an Acting Honorary Secretary. Professor J. B. Cleland nominated Mr. Ralph Walter Segnit., seconded by Mr. J. F. Bailey. There being no other nomination, Mr. Segnit was declared elected.

   It was agreed, on the proposition of Professor Harvey Johnston, that the thanks of the Society be recorded for the valuable services rendered by Dr. Robert Pulleine as the Honorary Secretary, and that good wishes be extended to Dr. Pulleine on his journey abroad.

   It was proposed by Mr. B. S. ROACH, seconded by Professor HARVEY JOHNSTON, that all cheques on the funds of the Society be signed by the Acting Honorary Secretary, Mr. Ralph W. Segnit. Carried.

2. Of Fellows. Frank Mitton Angel, Accountant, 34 Fullarton Road, Parkside; Bernard Charles Cotton, Assistant Conchologist, S.A. Museum; John Whinham Hosking, Dentist, 77 Sydenham Road, Norwood, and

3. Of Associate. William Paton Cleland, Science Student, University, Adelaide.

   After a ballot had been taken, the above-mentioned gentlemen were declared elected.

VISITOR.—The Chairman extended a welcome to Mrs. GRACE, of Wentworth, N.S.W., who is interested in aboriginal matters and stone culture.

SUGGESTIONS FOR AUTHORS.—Professor W. HOWCHIN drew the attention of the Fellows to the "Suggestions for the Guidance of Authors," as published in the Proceedings of the Society, vol. lii., 1928, p. 265.

Professor J. B. CLELAND moved that the congratulations of the Society be tendered to Mr. J. M. Black on his completion and publication of the "Flora of South Australia."

The motion was seconded by Mr. J. F. BAILEY, who referred to the great value of this work to the Botanist. Carried.

Mr. J. M. BLACK thanked the members for the expressions tendered.

PAPERS—

1. "A Census of the Marine Algae of South Australia," by A. H. S. LUCAS, M.A., B.Sc., of Sydney, communicated by Professor Cleland. He said the paper included about 300 species of marine algae from the coast of South Australia, with an indication of the districts where they are to be found. New species are described. Specimens from the coast of the Great Australian Bight and Kangaroo Island would be very welcome to Mr. Lucas for further investigation.

2. "The Fauna of Dirk Hartog Island—Aves and Polyplacophora," by EDWIN ASHBY, F.L.S.

EXHIBITS.—Dr. FENNER exhibited a map of the River Murray on which is detailed the essential happenings of the Discovery and Exploration of Captain Charles Sturt, 1829-30, which has been prepared by the Historical Memorial Committee in connection with the Sturt Centenary Celebrations. Mr. ASHBY showed

two samples of a very rare chiton named *Ornithochiton ashbyi,* from Port Willunga, collected there by Mr. W. C. Johnston last Easter. Only five examples of this shell have previously been found. It is the only species of chiton found in our State that possesses the organs known as "eyes." He also showed a series of the rare *Ischnochiton ptychius.* These show beautiful patterns of varied colours, of which pink is the most striking. They were collected at the same place and time by Mr. Johnston, and are the most beautiful series of this species yet obtained. Mr. A. M. LEA exhibited a series of interesting insects and beetles from New Guinea.

ORDINARY MEETING, JULY 11, 1929.

Dr. CHARLES FENNER, V.P., was in the chair, and 47 Fellows were present.

THE CHAIRMAN welcomed the Patron of the Society, His Excellency Brig.-Gen. Sir A. G. A. Hore-Ruthven, V.C., K.C.M.G., C.B., D.S.O., who was attended by the Hon. Hugh Grosvenor, A.D.C., to the meeting.

HIS EXCELLENCY, in reply, said that he was looking forward with interest to the proceedings of the evening.

Owing to the special nature of the business on the agenda, Mr. B. S. ROACH moved, and Professor RICHARDSON seconded: "That the Minutes of the previous Ordinary Meeting, held June 13, 1929, be taken as read."

THE CHAIRMAN intimated that he had previously read the Minutes, and gave an assurance that they were a faithful record of that meeting. Carried.

THE CHAIRMAN extended a welcome to Professor Sir Edgeworth David Honorary Fellow, to the meeting.

Congratulations were then extended by THE CHAIRMAN to Professor T. Harvey Johnston, on behalf of the Society, on his election to the staff of Sir Douglas Mawson in connection with the British Antarctic Expedition.

NOMINATIONS.—Lance Strother Walters, Technologist, 157 Buxton Street, North Adelaide; Alec. Gordon Paull, B.A., B.Sc., Head Master, 10 Milton Avenue, Fullarton Estate; Harold G. Pank, Optician, 75 Rundle Street, Adelaide; Martin Richard Freney, Geologist, 14 Holden Street, Kensington Park; Martin Raphael Freney, University Student, 14 Holden Street, Kensington Park.

PAPERS—

1. "Notes on the Geology of the Great Pyap Bend (Loxton), River Murray Basin, and Remarks on the Geological History of the River Murray," by Professor WALTER HOWCHIN.
2. "The Volcanic Soil of Mount Gambier," by Professor J. A. PRESCOTT and C. S. PIPER.
3. "A Geographical Enquiry into the Growth, Distribution and Movement of Population in South Australia, 1836-1927," by CHARLES FENNER, D.Sc.

EXHIBIT.—THE CHAIRMAN exhibited a book from the library of the Royal Geographical Society of S.A. which had been the personal property of King Charles II., the founder of the Royal Society in England.

Professor Sir EDGEWORTH DAVID referred to the value of the three papers presented, and then moved a vote of thanks to the authors.

In supporting the remarks of Sir Edgeworth, HIS EXCELLENCY THE GOVERNOR congratulated the lecturers on the clear manner in which the papers had been presented. He deemed it a privilege to have been present, and congratulated the Society on the splendid work it was doing. He expressed the hope that he would have an opportunity to be present at a future date to take part in their discussions.

The vote of thanks was carried with acclamation.

Ordinary Meeting, August 8, 1929.

Owing to the absence of the President and both Vice-Presidents, Mr. A. M. Lea was elected as Chairman. Twenty-three members were present.

The Minutes of the Ordinary Meeting, held July 11, 1929, were read and confirmed.

Nominations.—The following nominations were read:—William Christie, M.B., B.S., Medical Inspector of Schools, Education Department; Everard F. S. Fricke, B.Ag.Sc., Agronomist, Waite Agricultural Research Institute; Frederick Clarence Martin, B.A., Teacher, Technical High School, Thebarton.

Elections.—The ballot having been taken, the following were unanimously elected:—Lance Strother Walters, Technologist, 157 Buxton Street, North Adelaide; Alec. Gordon Paull, B.A., B.Sc., Head Master, 10 Milton Avenue, Fullarton Estate; Harold G. Pank, Optician, 75 Rundle Street, Adelaide; Martin Richard Freney, Geologist, 14 Holden Street, Kensington Park; Martin Raphael Freney, University Student, 14 Holden Street, Kensington Park; Charles William Laubman, Optician, 75 Rundle Street, Adelaide.

Papers—

1. "Australian Acanthocephala, No. 1. Census of Recorded Hosts and Parasites," by Professor Harvey Johnston and Effie W. Deland, B.Sc, and
2. "Australian Acanthocephala, No. 2," by Professor Harvey Johnston and Effie W. Deland, B.Sc.
3. "Magmatic Differentiation at Mannum, South Australia," by A. R. Alderman, M.Sc.
4. "Notes on Some Miscellaneous Coleoptera, VII.," by A. M. Lea.
5. "Unique Example of Aboriginal Rock Carving," by C. P. Mountford.
   The Rev. J. C. Jennison said that this design may have been brought down from Central Queensland (the nearest place where crocodiles are now found, to the locality mentioned by Mr. Mountford), in the form of a "legend and memory" by natives. He agreed that 1,000 miles was a long way to carry actual remains. Many examples of a similarity in speech are recorded between different tribes of the Musgrave Ranges and the Far North.

Exhibit.—Mr. Lea exhibited a collection of Orthoptera from New Guinea, including a Green Katydid larger than any other insect in the Museum from that country. Also a collection of insects from the Anglo-Egyptian Soudan presented by Sir Joseph Verco.

Ordinary Meeting, September 12, 1929.

Dr. Charles Fenner, Vice-President, occupied the chair, and 33 members were present.

The Minutes of the Ordinary Meeting, held August 8, 1929, were read and confirmed.

Correspondence.—The Chairman read a letter from the Secretary of the Council for Scientific and Industrial Research, drawing attention to the appointment of a Draughtsman and Artist.

Professor Cleland then moved that God speed and best wishes be extended to Sir Douglas Mawson and Professor T. Harvey Johnston on their journey, and wishing them success in connection with the Expedition in the "Discovery" to the Antarctic. Professor Cleland referred to the thoroughness with which Sir Douglas had fitted out the ship, and to the qualities of Professor Harvey Johnston as a Scientist.

The motion was seconded by Mr. MADIGAN, who briefly outlined the route to be followed round the Antarctic coast.

The motion was supported by THE CHAIRMAN, and was carried unanimously.

Professor HARVEY JOHNSTON thanked the Fellows for kind references to Sir Douglas Mawson and himself, and said that he appreciated the honour and confidence reposed in him by Sir Douglas and his committee in asking him to take charge of the Biological Section.

THE CHAIRMAN welcomed Mr. Madigan on his return from his Aerial Survey Expedition across part of Central Australia.

The members passed a resolution that a letter of congratulation be sent to Mr. W. J. Adey on his appointment to the position of Director of Education to this State.

THE CHAIRMAN extended a welcome to two new Fellows, Mr. Richard Martin Freney and his son.

The Rev. J. C. JENNISON moved the following:—"That in view of the urgent need of anti-scorbutic foods for the aborigines of Hermansburg District, requests be made to the Commonwealth Government to continue the free transport of fruit and vegetables (generously and gratuitously contributed by the growers), for the relief of the sufferers, over the Commonwealth Railway to Stuart, until further supplies be found unnecessary."

The motion was seconded by Mr KIMBER, and supported by Professor CLELAND. Unanimously carried.

THE CHAIRMAN stated that Professor Cleland would like it announced that Mr. A. H. S. Lucas, who is engaged in the study of the Australian Marine Algae and who has undertaken to contribute a handbook on the South Australian species, has forwarded to him a number of identified species from this State, which may be consulted by anyone desirous of identifying a specimen.

ELECTIONS.—A ballot having been taken, the following were unanimously elected as Fellows:—William Christie, M.B., B.S.; Everard F. S. Fricke, B.Ag.Sc.; Frederick Clarence Martin, B.A.

PAPERS—

1. "On Crystal Forms of Pyromorphite and Stolzite," by J. O. G. GLASTONBURY, B.Sc., and F. J. SEMMENS, B.Sc. Communicated by C. T. Madigan, M.A., B.Sc.
2. "Additions to the Flora of South Australia, No. 27," by J. M. BLACK.
3. "New Australian Lepidoptera," by A. JEFFERIS TURNER, M.D., F.E.S. Read by Arthur M. Lea, F.E.S.
4. "An Interesting New Thrips from Australia," by DUDLEY MOULTON. Communicated by Arthur M. Lea, F.E.S.
5. "Notes on and Descriptions of Chalcid Wasps in the South Australian Museum," by A. A. GIRAULT. Communicated by Arthur M. Lea, F.E.S.
6. "The Spreading Tendencies of Solutions of Various Acids and Salts upon a Clean Mercury Surface," by R. G. MITTON, B.Sc. Communicated by Roy S. Burdon, B.Sc.

EXHIBITS.—Sir DOUGLAS MAWSON exhibited Fossil Algae from the Flinders Ranges, and said that the Algae Limestones cover a very wide area. They are found in association above and below the Archaeocyathinae. Also below the Ordovician formation of the McDonnell Ranges. Predominant amongst the Algae is a Cryptozöon-like form. At Wooltana thick limestone beds above tillite, which have been regarded as equivalents of the Brighton limestones of the Adelaide Series are found to be of Algae origin. Owing to Sir Douglas Mawson being absent during the earlier part of the meeting, THE CHAIRMAN then addressed him

and expressed the sentiments contained in the resolution passed during his absence that evening. Sir DOUGLAS thanked the Fellows for the kind thought which prompted the motion. He referred to the coming journey, and detailed the probable route round the Antarctic coast from south of Africa to south of Australia which it was proposed to explore. There were to be no "land parties," the expedition being a "Life on Ship." He expected the "Discovery" to return to Australia early in April, 1930, calling at Albany, Adelaide and Melbourne.

ANNUAL MEETING, OCTOBER 10, 1929.

The chair was occupied by the Vice-President, Dr. CHARLES FENNER, who apologised for the absence of the President, who was out of the State in connection with the Coal Commission. Twenty-two members were present.

Minutes of the Ordinary Meeting, held September, 12, 1929, were read and confirmed.

THE CHAIRMAN welcomed two new Fellows, Dr. William Christie and Mr. F. C. Martin.

ANNUAL REPORT.—THE ACTING HON. SECRETARY presented the Annual Report for the year ended September 30, 1929. It was moved by Mr. Bailey, seconded by Dr. Campbell, that the report be adopted. Carried.

BALANCE SHEET.—The Financial Statement and Balance Sheet were presented by THE HON. TREASURER. It was moved by Mr. Black, seconded by Dr. Christie, that the same be adopted. Carried.

ELECTION OF OFFICERS FOR THE YEAR 1929-1930.—

1. *President*—Professor Howchin moved that Dr. L. Keith Ward be re-elected President for the coming year, pointing out that the Society had not had the full benefit of Dr. Ward's valuable services owing to his absence from the State on other important business in connection with the Coal Commission. The nomination was seconded by Dr. Chas. Fenner, and carried unanimously.
2. *Vice-Presidents*—Professor T. Harvey Johnston and Dr. Chas. Fenner were re-elected Vice-Presidents.
3. *Treasurer*—Mr. B. S. Roach was unanimously re-elected Treasurer.
4. *Members of Council*—The two senior members, namely, Mr. Black and Professor J. A. Prescott, retired, but offered themselves for re-election. It was moved by Dr. Davidson, seconded by Mr. Elston, that Mr. Black and Professor Prescott be re-elected Members of the Council. Carried unanimously.
5. *Auditors*—Mr. W. Champion Hackett and Mr. O. Glastonbury were re-elected Auditors.

It was agreed that a letter expressing the thanks of the Society be sent to Mr. Whitbread in recognition of his valuable services for the past 21 years as Hon. Auditor.

On behalf of the President, Dr. L. Keith Ward, Mr. B. S. ROACH read an Obituary Notice of Professor Sir W. Baldwin Spencer, F.R.S. (see p. 391).

It was moved and seconded that the same be printed in the Annual Proceedings. Carried.

PAPERS—

1. "Australian Coleoptera, Part VI.," by ALBERT H. ELSTON, F.E.S.
2. "Floristics and Ecology of the Mallee," by J. G. WOOD, M.Sc.
3. "Polarity in *Casuarina paludosa*," by T. T. COLQUHOUN, B.Sc. Communicated by J. G. Wood, M.Sc.

ANNUAL REPORT.

FOR THE YEAR ENDED SEPTEMBER 30, 1929.

The interest shown by the Fellows in the proceedings during the year has been maintained. The average attendance at the meetings has been 35, a number which compares favourably with that of previous years.

The Patron of the Society, His Excellency Brig.-Gen. Sir A. G. A. Hore-Ruthven, attended the Monthly Ordinary Meeting held on July 11, 1929.

The President, Dr. L. Keith Ward, was appointed a member of the Coal Commission by the Commonwealth and New South Wales Governments. This necessitated his absence from the State from June to the end of the year. In his absence the chair was occupied by Dr. Charles Fenner, Vice-President, and at one meeting, in the absence of both Vice-Presidents, by Mr. Arthur M. Lea.

An Expedition of great interest and which is now *en route* to the Antarctic, is led by Sir Douglas Mawson, F.R.S., who is a past President of the Society.

The Council appointed Professor T. Harvey Johnston as the representative of the Society on the Board of Governors of the Public Library, Museum and Art Gallery. He resigned, however, before the completion of his term, owing to his departure for the Antarctic. Dr. Charles Fenner was appointed to fill the vacancy.

The Honorary Secretary, Dr. Robert Pulleine, was granted extended leave of absence, to enable him to undertake a journey abroad, and Mr. Ralph W. Segnit was elected as the Acting Honorary Secretary.

Mr. M. S. Hawker was appointed to represent the Society on the Fauna and Flora Board in place of Dr. Robert Pulleine, resigned.

Congratulations were extended to Professor T. Harvey Johnston on his selection to the scientific staff of the British, Australian, and New Zealand Antarctic Expedition, which is led by Sir Douglas Mawson.

Dr. Charles Fenner received the congratulations of the Society on having been awarded the David Syme Prize and Medal for Research.

Early in the year the Fellows of the Society unanimously endorsed the proposal to found a Medal, to be awarded for Research by this Society. It is to be known as the Sir Joseph Verco Medal, in recognition of the eminent services rendered by Sir Joseph to this Society.

Professor Walter Howchin, F.G.S., received the congratulations of the Society on being the first recipient of the Sir Joseph Verco Medal. (The addresses in connection with the presentation are printed in the Proceedings, p. 382.)

Professor Sir T. W. Edgeworth David, F.R.S., an Honorary Fellow of the Society, attended two meetings during the year. On April 11 Sir Edgeworth presented a paper on "Further Notes on the Fossils of the Adelaide Series (Lipalian)," which he illustrated with lantern slides.

Mr. C. T. Madigan, a Fellow of this Society, undertook an Aerial Survey Expedition over Lake Eyre and unknown parts of the Interior, under the auspices of the Royal Geographical Society of Australasia, S.A. Branch.

The Board for Anthropological Research, Adelaide University, sent another Expedition to the Interior, in which the following Fellows took part:— Professor T. Harvey Johnston, Professor J. B. Cleland, Dr. T. D. Campbell, Professor E. Harold Davies, Dr. H. K. Fry, Mr. Herbert M. Hale, Mr. N. B. Tindale, and Mr. B. J. Maegraith.

During the year, Professor E. Harold Davies, Mus.Doc., gave a recital of Records of Aboriginal Songs, taken during the Adelaide University Anthropological Expedition to Koonibba in August of 1928.

Papers.—A paper of great interest to this State was read by Dr. Charles Fenner on the Growth, Distribution and Movement of Population in South Australia, 1836-1927.

Zoological papers bulk large in the Annual Proceedings. These include contributions by Th. Mortensen (Copenhagen), Communicated by Professor T. Harvey Johnston; also by Stanley Hirst; Herbert M. Hale; Dr. Mary Rathbun, Communicated by Herbert M. Hale; Professor T. Brailsford Robertson; A. H. S. Lucas, Communicated by Professor Cleland; Edwin Ashby; Professor T. Harvey Johnston and Effie W. Deland; Arthur M. Lea; A. Jefferis Turner; Dudley Moulton, Communicated by Arthur M. Lea; A. A. Girault, Communicated by Arthur M. Lea; and A. H. Elston.

Geological papers were contributed by Sir T. Edgeworth David; Professor W. Howchin, J. O. G. Glastonbury and F. J. Semmens, Communicated by C. T. Madigan; A. R. Alderman; and Ralph W. Segnit.

Botanical papers include contributions by J. M. Black; Professor Prescott and C. S. Piper; J. G. Wood; and T. T. Colquhoun, Communicated by J. G. Wood.

A physics paper was presented by R. G. Mitton, Communicated by R. S. Burden.

A paper on Anthropology was presented by C. P. Mountford.

The membership of the Society shows a steady increase, the number of Fellows elected during the year being 22. The membership roll at the close of the year is as follows:—Honorary Fellows, 5; Fellows, 159; Associate, 1. Total. 165.

During the year the Society has suffered loss by death of two Fellows:—Professor Sir W. Baldwin Spencer, F.R.S. (who was elected an Honorary Fellow in 1926), and Mr. Leslie Napier Birks. Obituary Notices of Professor Sir W. Baldwin Spencer, Sir George Knibbs, and Mr. R. H. Cambage were read by the President.

The Council has met on 12 occasions, *i.e.*, 9 Ordinary and 3 Special Meetings, the attendances being as follows:—Dr. L. Keith Ward, 9; Professor T. Harvey Johnston, 7; Dr. Charles Fenner, 9; Mr. B. S. Roach, 12; Professor Walter Howchin, 12; Professor J. H. Prescott, 5; Mr. J. F. Bailey, 11; Mr. Arthur Lea, 10; Sir Joseph Verco, 0; Mr. J. M. Black, 11; Dr. T. D. Campbell, 9; Dr. Robert Pulleine, 7; Mr. Ralph W. Segnit, 5.

The absence of the President from three meetings was due to his election as a member of the Coal Commission, which necessitated his absence from the State; Dr. Campbell was in the Interior of Australia during the August meeting, and Professor T. Harvey Johnston from two meetings, due to his absence from the State in connection with the Antarctic Expedition. Sir Joseph Verco was prevented from attendance for health reasons. Mr. Ralph W. Segnit was elected Acting Honorary Secretary in June, 1929.

L. Keith Ward, *President.*

Ralph W. Segnit, *Acting Hon. Sec.*

OBITUARY NOTICE.

SIR WALTER BALDWIN SPENCER.

Sir Walter Baldwin Spencer, an Honorary Fellow of this Society, died suddenly in July, 1929, while engaged in anthropological researches in South America. Leaving the biological school of Oxford in 1887, he occupied the Chair of Biology in the University of Melbourne until his retirement in 1920. Sir

Baldwin made many contributions to our knowledge of the fauna of the Australasian region, the most notable being his study of the pineal eye in Lacertilia. He held the post of Zoologist in the Horn Expedition to Central Australia in 1894, and wrote the reports on the Mammalia, Amphibia, and Crustacea, as well as the Narrative of the Expedition.

In the course of this journey of scientific exploration Sir Baldwin met F. J. Gillen, with whom he collaborated in a great series of studies dealing with the culture of the Australian aborigines. The basal value of this work to the science of anthropology has been recognised throughout the world.

Sir Baldwin Spencer acted also, during the early stages of the administration of the Northern Territory by the Commonwealth Government, as Special Commissioner and Chief Protector of the aborigines.

Many honours were conferred upon him in recognition of his distinguished services to science. He was a Fellow of the Royal Society; an Honorary Fellow of Exeter and Lincoln Colleges in Oxford; a Corresponding Member of the Zoological Society of London; and an Honorary Fellow of the Anthropological Institutes of Great Britain, Italy, and Washington. Sir Baldwin took a leading part in the scientific life of his adopted country and held, *inter alia*, the offices of President of the Royal Society of Victoria and President of the Australasian Association for the Advancement of Science.

This Society was honoured by the enrolment of his name among its Honorary Fellows, and will not cease to mourn the death of so distinguished an investigator, who made many original contributions to science and who left a record of his observations that is notable for its literary and artistic grace.

L. K. W.

ROYAL SOCIETY OF SOUTH AUSTRALIA (INCORPORATED).

Receipts and Payments for the Year ended September 30, 1929.

RECEIPTS.

	£	s.	d.	£	s.	d.
To Balance, October 1, 1928				633	10	2
„ Subscriptions	145	19	0			
„ Field Naturalists' Section	44	5	0			
				190	4	0
„ Grants from S.A. Government—						
On Subscriptions	153	10	6			
For Printing Reports and Scientific Investigations	150	0	0			
				303	10	6
„ Use of Room by other Societies				4	9	6
„ Sale of Publications				7	5	0
„ Payment for Extra Illustrations				2	10	0
„ Interest—						
Savings Bank Account	24	1	5			
Transferred from Endowment Fund	185	7	4			
				209	8	9
				£1,350	17	11

PAYMENTS.

	£	s.	d.	£	s.	d.
By Transactions—						
Printing	271	4	6			
Illustrating	95	2	0			
Publishing	13	4	10			
				379	11	4
„ Grant to Field Naturalists' Section				50	0	0
„ Library						
Librarian	69	16	0			
Bookbinding	27	18	6			
Freight on Books	1	4	2			
				98	18	8
„ Sundries—						
Cleaning and Lighting	5	10	6			
Printing, Postage and Stationery	21	19	2			
Insurance	6	15	0			
Lantern Repairs	3	10	0			
Sir Joseph Verco Medal	28	17	8			
Bank Account Fee	0	5	0			
				66	17	4
„ Balance, September 30, 1929—						
Savings Bank of South Australia	709	2	7			
Bank of Australasia	46	8	0			
				755	10	7
				£1,350	17	11

Audited and found correct,

O. GLASTONBURY, A.A.I.S., A.F.I.A., } Hon.
HOWARD WHITBREAD, } Auditors.

Adelaide, October 3, 1929.

B. S. ROACH, Hon. Treasurer.

ENDOWMENT FUND.

As at September 30, 1929.

(Capital .. £4,069 6s. 10d.)

	£	s.	d.	£	s.	d.
1928—October 1.						
To Balance, S.A. Government Stock ..	4,064	18	9			
Savings Bank ..	4	8	1			
				4,069	6	10
1929—September 30.						
,, Interest received				185	7	4
				£4,254	14	2

		£	s.	d.	£	s.	d.
1929—September 30.							
By Revenue Account					185	7	4
,, £500 S.A. Govt. Stock	@ 3%	292	8	9			
,, £2,000 S.A. Govt. Stock	@ 3¾%	1,997	10	0			
,, £900 S.A. Govt. Stock	@ 5¼%	900	0	0			
,, £875 S.A. Govt. Stock	@ 5½%	875	0	0			
		4,064	18	9			
,, Savings Bank Account		4	8	1			
					4,069	6	10
					£4,254	14	2

Audited and found correct,

O. GLASTONBURY, A.A.I.S., A.F.I.A., } Hon.
HOWARD WHITBREAD, } Auditors.

B. S. ROACH, Hon. Treasurer.

Adelaide, October 3, 1929.

THE ENDOWMENT AND SCIENTIFIC RESEARCH FUND.

1902.—On the motion of the late Samuel Dixon it was resolved that steps be taken for the incorporation of the Society and the establishment of an Endowment and Scientific Research Fund. Vol. xxvi. pp. 327-8.

1903.—The incorporation of the Society was duly effected and announced. Vol. xxvii., pp. 314-5.

1905.—The President (Dr. J. C. Verco) offered to give £1,000 to the Fund on certain conditions. Vol. xxix., p. 339.

1929.—The following are particulars of the contributions received and other sources of revenue in support of the Fund up to date:—

SUMMARY OF THE ENDOWMENT FUND.

(Capital £4,069 6s. 10d.)

Contributions.

	£	s.	d.	£	s.	d.	£	s.	d.
Donations									
1908, Dr. J. C. Verco	1,000	0	0						
1908, Thomas Scarfe	1,000	0	0						
1911, Dr. Verco	150	0	0						
1913, Dr. Verco	120	0	0						
Mrs. Ellen Peterswald	100	0	0						
Small Sums	6	0	0						
				2,376	0	0			
Bequests—									
1917, R. Barr Smith	1,005	16	8						
1920, Sir Edwin Smith	200	0	0						
				1,205	16	8			
Life Members' Subscriptions				225	0	0			
*Interest and Discounts				156	3	10			
From Current Account				106	6	4			
							4,069	6	10

*Interest on investments has, in the main, been transferred to general revenue for the publication of scientific papers. See Balance Sheets.

GRANTS MADE IN AID OF SCIENTIFIC RESEARCH.

	£	s.	d.
1916, G. H. Hardy, "Investigations into the Flight of Birds"	15	0	0
1916, Miss H. A. Rennie, "Biology of *Lobelia gibbosa*"	2	2	0
1921, F. R. Marston, "Possibility of obtaining from Azine precipitate samples of pure Proteolytic Enzymes"	30	0	0
1921, Prof. Wood Jones, "Investigations of the Fauna and Flora of Nuyts Archipelago"	44	16	7

DONATIONS TO THE LIBRARY

FOR THE YEAR ENDED SEPTEMBER 30, 1929.

TRANSACTIONS, JOURNALS, REPORTS, ETC.,

presented by the respective governments, societies, and editors.

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ADELAIDE UNIVERSITY. *Animal Products Research.* Rep., no. 8. Adel. 1928.
BRITISH SCIENCE GUILD (S. A. BR.). From Government Printer, Adelaide:—
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Reptiles and Amphibians of S.A., by E. R. Waite.
Crustaceans of South Australia, by H. M. Hale.
Building of S.A. and the Succession of Life, pts. 1-2, by W. Howchin.
Flora of S.A., pts. 1-4, by J. M. Black.
Mammals of S.A., pts. 1-3, by F. Wood-Jones.
PUBLIC LIBRARY, MUSEUM, AND ART GALLERY OF S.A. Rep., 1928-29. Adel.
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LINNEAN SOCIETY OF N.S.W. Proc., v. 54, pt. 1-3. Index to v. 1-50.
MAIDEN, J. H. Critical revision of the genus Eucalyptus, pt. 70. Syd. 1928.
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Cambridge University Press. Andaman Islanders. Climate of Africa. Gravels of East Anglia. History of the Cambridge University Press. History of the Melanesian Society, 2 vols. Kinship Organisations and Group Marriage in Australia. Melanesians of British New Guinea. Our Early Ancestors. Place-names of Northumberland and Durham. Southern New Hebrides. Theory of Experimental Electricity.
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Entomological Society. Proc., v. 3. Trans., v. 76; 77, pt. 1. Lond.
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LIST OF FELLOWS, MEMBERS, ETC.

AS EXISTING ON SEPTEMBER 30, 1929.

Those marked with an asterisk (*) have contributed papers published in the Society's Transactions. Those marked with a dagger (†) are Life Members.

Any change in address or any other changes should be notified to the Secretary.

Note.—The publications of the Society will not be sent to those whose subscriptions are in arrear.

Date of Election.

HONORARY FELLOWS.

1910. *BRAGG, SIR W. H., K.B.E., M.A., D.Sc., F.R.S., Director of the Royal Institution, Albemarle Street, London (Fellow 1886).
1926. *CHAPMAN, F., A.L.S., National Museum, Melbourne.
1897. *DAVID, SIR T. W. EDGEWORTH, K.B.E., C.M.G., D.S.O., B.A., D.Sc., F.R.S., F.G.S., Emeritus Professor of Geology, University of Sydney, Coringah, Sherbroke Road, Hornsby, N.S.W.
1898. *MEYRICK, E. T., B.A., F.R.S., F.Z.S., Thornhanger, Marlborough, Wilts, England.
1894. *WILSON, J. T., M.D., Ch.M., Professor of Anatomy, Cambridge University, England

FELLOWS.

1926. ABEL, L. M. Chapman Camp, British Columbia.
1925. ADEY, W. J., 32 High Street, Burnside, S.A.
1927. *ALDERMAN, A. R., M.Sc., West Terrace, Kensington Gardens, S.A.
1929. ANGEL FRANK M., Box 1327G, G.P.O., Adelaide.
1895. *†ASHBY, EDWIN, F.L.S., M.B.O.U., Blackwood, S.A.
1917. BAILEY, J. F., Director Botanic Garden, Adelaide.
1902. *BAKER, W. H., King's Park, S.A.
1926. BECK, B. B., 127 Fullarton Road, Myrtle Bank, S.A.
1928. BEST, R. J., M.Sc., A.A.C.I., Waite Agricultural Research Institute, Glen Osmond.
1907. *BLACK, J. M., 82 Brougham Place, North Adelaide.
1912. *BROUGHTON, A. C., Mt. Helena, Western Australia.
1902. *BLACK, J. M., 82 Brougham Place, North Adelaide.
1912. *BROUGHTON, A. C., The "Grosvenor," North Terrace, Adelaide.
1911. BROWN, EDGAR J., M.B., D.P.H., 175 North Terrace.
1924. BROWNE, J. W., B.Ch., 169 North Terrace, Adelaide.
1916. *BULL, LIONEL B., D.V.Sc., Laboratory, Adelaide Hospital
1923. BURDON, ROY S., B.Sc., University of Adelaide.
1921. BURTON, R. J., Belair.
1922. *CAMPBELL, T. D., D.D.Sc., Dental Dept., Adelaide Hospital, Frome Road.
1924. CAVENAGH-MAINWARING, W. R., M.B., B.S., 207 North Terrace.
1907. *CHAPMAN, R. W., C.M.G., M.A., B.C.E., F.R.A.S., Professor of Engineering and Mechanics, University of Adelaide.
1904. CHRISTIE, W., c/o Griffiths Bros., Hindmarsh Square, Adelaide.
1929. CHRISTIE, W., M.B., B.S., Education Department, Flinders Street, Adelaide.
1895. *CLELAND, JOHN B., M.D., Professor of Pathology, University of Adelaide.
1907. *COOKE, W. T., D.Sc., Lecturer, University of Adelaide.
1929. COTTON, BERNARD C., S.A. Museum, Adelaide.
1924. DE CRESPIGNY, C. T. C., D.S.O., M.D., 219 North Terrace, Adelaide.
1916. DARLING, H. G., Franklin Street, Adelaide.
1929. DAVIDSON, JAMES, D.Sc., Waite Agricultural Research Institute, Glen Osmond.
1928. DAVIES, J. G., B.Sc., Ph. D., Waite Agricultural Research Institute, Glen Osmond.
1927. *DAVIES, Prof. E. HAROLD, Mus.Doc., The University, Adelaide.
1927. DAWSON, BERNARD, M.D., F.R.C.S., 8 King William Street, Adelaide.
1928. *DELAND, Miss EFFIE W., B.Sc., 34 Trevelyan Street, Wayville.
1915. *DODD, ALAN P., Prickly Pear Laboratory, Sherwood, Brisbane.
1921. DUTTON, G. H., B.Sc., F.G.S., Agricultural High School, Murray Bridge.
1911. DUTTON, H. H., M.A. (Oxon.), Victor Harbour.
1902. *EDQUIST, A. G., 19 Farrell Street, Glenelg.
1918. *ELSTON, A. H., F.E.S., "Llandyssil," Aldgate.
1925. ENGLAND, H. N., B.Sc., Commonwealth Research Station, Griffith, N.S.W.
1917. *FENNER, CHAS. A. E., D.Sc., 42 Alexandra Avenue, Rose Park.
1927. *FINLAYSON, H. H., The University of Adelaide.
1929. FRENEY, M. RAPHAEL, 14 Holden Street, Kensington Park.

Date of Election.

1929. FRENEY, M. RICHARD, 14 Holden Street, Kensington Park.
1929. FRICKE, EVERARD F. S., B.Ag.Sc., Waite Agricultural Research Institute, Glen Osmond.
1923. FRY, H. K., D.S.O., M.B., B.S., B.Sc., Glen Osmond Road, Parkside.
1919 †GLASTONBURY, O. A., Adelaide Cement Co., Brookman Buildings, Grenfell Street.
1923. GLOVER, C. J. R., Stanley Street, North Adelaide.
1927. GODFREY, F. K., Robert Street, Payneham, S.A.
1904. GORDON, DAVID, 72 Third Avenue, St. Peters.
1925. †GOSSE, J. H., 31 Grenfell Street, Adelaide.
1880. *GOYDER, GEORGE, A.M., B.Sc., F.G.S., 232 East Terrace, Adelaide.
1910. *GRANT, KERR, M.Sc., Professor of Physics, University of Adelaide.
1904. GRIFFITH, H., Hove, Brighton.
1916. HACKETT, W. CHAMPION, 35 Dequetteville Terrace, Kent Town.
1927. *HACKETT, Dr. C. J., 196 Prospect Road, Prospect, S.A.
1922. *HALE, H. M., The Curator, S.A. Museum, Adelaide.
1922. *HAM, WILLIAM, F.R.E.S., Teachers' College, Kintore Avenue, Adelaide.
1916. †HANCOCK, H. LIPSON, A.M.I.C.E., M.I.M.M., M.Am.I.M.E., Bundarra Road, Bellevue Hill, Sydney.
1924. HAWKER, Captain C. A. S., M.H.R., M.A., North Bungaree, via Yacka, South Australia.
1896. HAWKER, E. W., M.A., LL.B., F.C.S., East Bungaree, Clare.
1928. HAWKER, M. S., Adelaide Club, North Terrace.
1923. HILL, FLORENCE McCOY M., B.S., M.D., University of Adelaide.
1928. HIRST, A. S., F.L.S., University of Adelaide.
1927. HOLDAWAY, Mrs. E. D., M.Sc., Farnham Royal, England.
1926. HOLDAWAY, F. C., M.Sc., Ph.D., Farnham Royal, England.
1927. HOLDEN, E. W., B.Sc., Dequetteville Terrace, Kent Town, S.A.
1929. HOSKING, JOHN W., 77 Sydenham Road, Norwood.
1924. *HOSSFELD, PAUL S., M.Sc., Rabaul, Territory of New Guinea.
1883. *HOWCHIN, Professor WALTER, F.G.S., "Stonycroft," Goodwood East, S.A.
1928. HURCOMBE, Miss J. C., 95 Unley Road, New Parkside.
1928. IFOULD, PERCY, Kurralta, Burnside.
1918. *ISING, ERNEST H., c/o Superintendent's Office, S.A. Railways, Adelaide.
1912. *JACK, R. L., B.E., F.G.S., Assistant Government Geologist, Adelaide.
1893. JAMES, THOMAS, M.R.C.S., 9 Watson Avenue, Rose Park.
1918. *JENNISON, Rev. J. C., Kyre Avenue, Kingswood.
1910. *JOHNSON, E. A., M.D., M.R.C.S., Town Hall, Adelaide.
1921. *JOHNSTON, Professor T. HARVEY, M.A., D.Sc., University of Adelaide.
1920. *JONES, F. WOOD, M.B., B.S., M.R.C.S., L.R.C.P., D.Sc., F.R.S., Honolulu.
1923. JUDELL, LESTER M. W., B.Sc., Jamestown.
1926. JULIUS, EDWARD, Conservator of Forests, Adelaide.
1918. KIMBER, W. J., 28 Second Avenue, Joslin.
1929. LAUBMAN, C. W., 75 Rundle Street, Adelaide.
1915. *LAURIE, D. F., Agricultural Department, Victoria Square.
1897. *LEA, A. M., F.E.S., South Australian Museum, Adelaide.
1884. LENDON, A. A., M.D., M.R.C.S., 66 Brougham Place, North Adelaide.
1922. LENDON, GUY A., M.B., B.S., M.R.C.P., North Terrace.
1925. LEWIS, A., M.B., B.S., Adelaide Hospital.
1922. *MADIGAN, C. T., M.A., B.Sc., University of Adelaide.
1923. MARSHALL, J. C.. Darrock, Payneham.
1928. MAEGRAITH, B. J., The University, Adelaide.
1929. MARTIN, F. C., B.A., Technical High School, Thebarton.
1905. *MAWSON, SIR DOUGLAS, D.Sc., B.E., F.R.S., Professor of Geology, University, Adelaide.
1919. MAYO, HELEN M., M.D., 47 Melbourne Street, North Adelaide.
1920. MAYO, HERBERT, LL.B., Brookman Buildings, Grenfell Street.
1920. McGILP, JOHN NEIL, 252 Napier Terrace, King's Park.
1929. McLAUGHLIN, EUGENE, M.B., B.S., M.R.C.P., Adelaide Hospital.
1907. MELROSE, ROBERT T., Mount Pleasant.
1928. MELVILLE, L. G., B.Ec., F.I.A., Professor of Economics, University of Adelaide, Adelaide.
1924. MESSENT, P. S., M.B., B.S., 192 North Terrace.
1925. †MITCHELL, Professor SIR WILLIAM, K.C.M.G., M.A., D.Sc., The University, Adelaide.
1897. *MORGAN, A. M., M.B., Ch.B., 215 Brougham Place, North Adelaide.
1924. MORISON, A. J., Deputy Town Clerk, Town Hall, Adelaide.
1926. MOORE, A. P. R., D.DSc., 193 North Terrace, Adelaide.
1926. *MOUNTFORD, C. P., Postal Workshops, Adelaide.
1921. MOULDEN, OWEN M., M.B., B.S., Unley Road, Unley.
1925. †MURRAY, HON. SIR GEORGE, K.C.M.G., B.A., LL.M., Magill, S.A.
1925. NORTH, Rev. WM. O., Methodist Manse, Netherby.
1913. *OSBORN, T. G. B., D.Sc., Professor of Botany, University of Sydney.

Date of Election.

1927. Paltridge, T. B., B.Sc., Koonamore, via Waukaringa, S.A
1929. Pank, Harold G., 75 Rundle Street, Adelaide.
1929. Paull, Alec. G., B.A., B.Sc., 10 Milton Avenue, Fullarton Estate.
1924. Pearce, C., 33 Capper Street, Kent Town.
1927. Pennycuick, S. W., D.Sc., The University of Adelaide.
1924. Perkins, A. J., Director of Agriculture, Victoria Square.
1928. Phipps, Ivan F., Ph.D., Waite Agricultural Research Institute, Glen Osmond.
1926. *Piper, C. S., M.Sc., Waite Agricultural Research Institute, Glen Osmond.
1925. *Prescott, Professor J. A., M.Sc., A.I.C., Waite Agric. Research Institute, Glen Osmond.
1926. Price, A. Grenfell, M.A., F.R.G.S., St. Mark's College, North Adelaide.
1907. †*Pulleine, R. H., M.B., Ch.M., North Terrace, Adelaide.
1925. Richardson, Professor A. E. V., M.A., D.Sc., "Urrbrae." Glen Osmond, S.A.
1926. Riddell, P. D., Technical College, Newcastle, N.S.W.
1911. Roach, B. S., Education Department, Flinders Street, Adelaide.
1919. *Robertson, Professor T. B., D.Sc., D.Ph., University of Adelaide.
1924. Roeger, Miss M. T. P., c/o Central School, Goodwood.
1925. Rogers, L. S., B.D.Sc., 192 North Terrace.
1905. *Rogers, R. S., M.A., M.D., 52 Hutt Street.
1922. *Samuel, Geoffrey, M.Sc., University of Adelaide
1924. Sandford, J. Wallace, 75 Grenfell Street.
1928. Scott, A. E., B.Sc., 143 Rundle Street, Kent Town.
1924. *Segnit, Ralph W., M.A., B.Sc., Architect-in-Chief's Office, Victoria Square, Adelaide.
1891. Selway, W. H., Gilberton.
1926. *Sheard, Harold, Nuriootpa.
1928. Showell, H., 27 Dutton Terrace, Medindie.
1920. Simpson, A. A., C.M.G., C.B.E., F.R.G.S., Lockwood Road, Burnside.
1924. Simpson, Fred. N., Dequetteville Terrace, Kent Town.
1925. †Smith, T. E. Barr, B.A., 25 Currie Street, Adelaide.
1906. Snow, Francis H., National Mutual Buildings, King William Street.
1927. Stapleton, P. S., Henley Beach, South Australia.
1922. Sutton, J., Fullarton Road, Netherby.
1925. Symons, Ivor G., Church Street, Highgate.
1929. Taylor, John K., Waite Agricultural Research Institute, Glen Osmond.
1928. Taylor, Violet, 40 Eton Street, Malvern.
1929. Tee, Sidney F., Adelaide Hospital.
1923. Thomas, J. F., Tenterfield, N.S.W.
1923. *Thomas, R. G., B.Sc., 5 Trinity Street, St. Peters, S.A.
1923. *Tindale, N. B., South Australian Museum, Adelaide.
1894. *Turner, A. Jefferis, M.D., F.E.S., Wickham Terrace, Brisbane, Queensland.
1925. Turner, Dudley C., National Chambers, King William Street, Adelaide.
1878. *Verco, Sir Joseph C., M.D., F.R.C.S., North Terrace, Adelaide.
1926. Wainwright, J. W., B.A., 32 Florence Street, Fullarton Estate.
1924. Walker, W. D., M.B., B.S., B.Sc., c/o National Bank, King William Street.
1929. Walters, Lance S., 157 Buxton Street, North Adelaide.
1912. *Ward, Leonard Keith, B.A., B.E., D.Sc., Government Geologist, Adelaide.
1920. Weidenbach, W. W., A.S.A.S.M., Geological Department, Adelaide.
1904. Whitbread, Howard, c/o A. M. Bickford & Sons, Currie Street.
1920. *Wilton, Professor J. R., D.Sc., University of Adelaide.
1923. *Wood, J. G., M.Sc., University of Adelaide.
1927. Woodlands, Harold, Box 989 H, G.P.O.
1927. Woollard, Professor H. H., M.D., University of Adelaide.

Associate.

1929. Cleland, W. Paton, 31 Wattle Street, Fullarton.

ROYAL SOCIETY OF SOUTH AUSTRALIA
(INCORPORATED).

SECTION III.—PAPERS.

(Approved October 8, 1923.)

1. No paper which has not been previously approved by the Council shall be brought before the Society.

2. Every paper brought before the Society shall be immediately delivered to the Secretary.

3. The Council shall at its next or at a subsequent meeting decide whether such paper will be published.

4. If the Council decides to publish the paper in whole or in part, it and all copyrights thereof shall become the property of the Society, such copyrights to include all plates, maps, diagrams, and photographs reproduced in illustration of the paper; and all blocks used in such reproductions shall be the property of the Society. All manuscripts and original illustrations must be returned to the Editor with the corrected proofs.

5. All matter used in illustration of papers (whether photographs, prints, negatives, or drawings) remains the property of the authors. The illustrations shall be returned to the Secretary by the printer on publication of the volume, and shall be kept by him in safe custody for one year, unless previously claimed by the author. After the expiration of one year they may be disposed of as the Council shall direct.

6. If the Council decides not to publish a paper, either in whole or in part, the same shall be returned to the author, if he so desires.

7. All papers and other contributions published by the Society shall be subjected to editing by the Editor.

8. The author of any paper published by the Society shall be entitled to receive free of cost 25 copies of the same, and to obtain additional copies (not exceeding 75, unless the Council shall determine otherwise) upon paying the extra cost thereof. Every such copy shall include a statement that it is taken from the publications of the Society.

9. All contributions and excerpts intended for publication by the Society shall be clearly typed or written on one side of the paper only, and in accordance with the "Suggestions for the Guidance of Authors" published by the Society, ready for the printer.

10. A proof shall be submitted (if possible) to the author, who shall be allowed to make any slight amendments without cost, but if the corrections are excessive they must be paid for by him.

11. In order to secure correct reports, all papers and other contributions laid before the Society must be accompanied by short abstracts.

ROYAL SOCIETY OF SOUTH AUSTRALIA
(INCORPORATED).

SUGGESTIONS FOR THE GUIDANCE OF AUTHORS IN THE PREPARATION OF MSS. TO BE SUBMITTED TO THE SOCIETY.

1. The manuscript must be clearly written (especially in the case of scientific and technical terms), and in a form ready to be placed in the hands of the printer. It is a great advantage for MSS. to be typed, double spaced. If the paper be illustrated, the illustrations, maps, etc., must be supplied in a form ready for reproduction. Where reduction is required, detail and lettering must be proportionally enlarged. It may be necessary to return MSS. to authors for typing. In returning proofs to the Editor, the original copy should be included.

2. Uniformity must be preserved throughout in the use of capital letters, italics, abbreviations, punctuation, etc.

3. All generic and specific names must be underlined (denoting italics). Other scientific nomenclature must be in roman. Generic names must begin with a capital letter, and specific and varietal names (even where a proper name is used) must begin with non-capitals, as, for example, *Lovenia forbesi* T. Woods. (An exception to this rule is made in the case of botanical names, where the usage is to retain the capital letter in proper names.)

4. Diphthongs are not allowed; each vowel must be written separately, as, for example, Archaeocyathinae.

5. In the case of original descriptions the following abbreviations should be used: n. gen., n. sp., n. var.

6. Authors and authorities, following a name in roman, must be in italics; following a name in italics, to be in roman; when the species is transferred to another genus the name of the original author to be enclosed in parentheses. (No comma shall appear between the specific name and the name of the author.)

7. The names of Australian States are to be written in full in the text, but in the footnotes and synonymy are to be abbreviated as follow: -Australia, Aust.; New South Wales, N.S.W.; Victoria, Vict.; Tasmania, Tasm.; South Australia, S. Aust.; Western Australia, W. Aust.; Queensland, Qld.; North Australia, N. Aust.; Central Australia, C. Aust.; New Guinea, N. Guin.; New Zealand, N.Z.; Federal Capital Territory, F.C.T. Aust.

8. Symbols or abbreviations used to save trouble in writing, but not intended to appear as such in the printed text, are not allowable.

9. The maximum size of illustrations (maps excepted) to be 7½ inches x 5 inches for plates, and 7¾ inches x 5 inches for text figures.

10. Papers submitted to the Society for reading must be lodged at the Society's rooms at least a week before the meeting of Council, which is held on the fourth Thursday in each month, from March to November, inclusive.

Note regarding Abstracts.—The author is requested to supply two brief abstracts of his paper—one for local use, and another, not exceeding 50 words, to be sent to publications which cannot grant more space.

APPENDIX.

FIELD NATURALISTS' SECTION

OF THE

Royal Society of South Australia (Incorporated).

FORTY-SIXTH ANNUAL REPORT OF THE COMMITTEE

FOR THE YEAR ENDED AUGUST 31, 1929.

The work of the Section has been well maintained for the last twelve months, and the following report is presented for the information of members:—

MEMBERSHIP.—Last year's membership was 188, and of this total 118 were financial. The figures this year are 150 members, of which 110 are financial. While 17 new members were admitted, the losses were two by resignation and two by death.

EXCURSIONS.—Trips have been made to the coast, plains, foothills, river, forest, and the Gulf, whilst visits to the Museum, Botanic and private gardens provided much instruction. A more intense concentration of the study of wild life in the field, the source, after all, of our knowledge of Natural History, is desired. The Committee would like to see better attendances at the excursions, and more members taking up a definite line of study.

LECTURES.—Our standard of lectures has been well maintained, and we have been favoured with excellent lantern lectures by the following:—Dr. A. E. V. Richardson on "Nature Notes and Scenes in Japan and Java"; Mr. N. B. Tindale on "Aborigines of the West Coast"; Mr. R. W. Segnit, M.A., B.Sc., on "Oxford University Expedition to Spitzbergen"; Rev. A. M. Trengove on "Flinders Range and Further Inland"; Dr. H. Basedow, M.P., on "Some Critical Aspects of Australian Anthropology"; and Mr. H. M. Hale on "Mosquitoes, etc." Others who assisted with papers or lecturettes were:—Mr. W. Champion Hackett on "The Protection of Our Fauna and Flora"; Professor J. B. Cleland, M.D., a paper on "The Original Flora of the Adelaide Plains," and lecturettes on "Our Herbarium," and "Botanical Notes on a Trip North of Port Augusta," and "Observing Birds"; Mr. E. H. Ising on "Herbarium Work on Native Plants at Mile End, near Adelaide," "Botanical Notes on Alligator Creek and Mount Remarkable"; Mr. B. B. Beck on "A Trip to Alligator Creek"; and Mr. W. Ham on "Geological Specimens from Kingscote, K.I." Mr. J. F. Bailey gave a lecturette on "Some Australian Flowers." Messrs. W. J. Kimber, F. Trigg, Broadbent, H. Williams; Misses V. Taylor, Moore, J. Murray, and R. E. Kentish gave lecturettes or showed specimens in connection with the Shell Committee. Mr. F. B. Collins on "Insect Pests of the Dried Fruit Industry."

EXHIBITS.—Many members contributed to this important part of our programme, and the members are thanked for their interest in bringing objects of Natural History. Every exhibit brought to the meetings has created a certain amount of interest.

"The South Australian Naturalist."—Our Journal has been published regularly each quarter under the Editorship of Mr. W. Ham. The part to be issued this month (No. 4) will complete Volume X.

The subject of Botany has been dealt with by Professor J. B. Cleland and Mr. E. H. Ising, Aboriginal Rock Carvings by Mr. H. M. Hale, Fresh Water Fishes by Mr. C. Blewett, and Shell Studies by Mr. F. Trigg. The Committee hope to enlarge and further illustrate the Journal, and the Editor will be pleased to receive contributions in original Natural History observations, with illustrations. We have received £5 15s. 0d. from the Royal Society for this purpose.

Wild Flower Show, 1928.—The Annual Show was held on October 12 and 13 in the Adelaide Town Hall, and was made possible by the generosity of the Lord Mayor. The exhibition was up to the usual standard, and flowers were contributed by schools, mutual clubs, friends and members. Many branches of Natural History were represented, including Shells, Microscope subjects, Botany (pressed specimens and native timbers), Aquatic life (prepared by the S.A. Aquarium Society and the Education Department through Mr. Machell), Entomology, an exhibit of Butterflies, Beetles, etc., from the Museum, Wild Flower paintings, etc.

The Show proved successful, and £33 10s. 0d. profit was made.

Herbarium.—The work in the Herbarium has been continued under the able direction of Professor J. B. Cleland and Mr. J. G. Wood, M.Sc. A further quantity of specimens have been drafted into their order and filed in cardboard boxes. The painting of specimens with a poisonous mixture, and mounting of specimens, have proceeded a further stage. Lists of plants in the Morialta, Waterfall Gully, and Belair National Park Reserves have been prepared and are ready for publishing when funds permit. There is a large amount of work to be done, and more helpers are needed. The work is engaged in on certain Mondays, from 5 to 6 p.m.

Obituary.—In the death of Mr. Walter Gill, F.L.S., F.R.H.S., we have lost one of our oldest and best members. Mr. Gill was best known for his many lectures on Forestry and Forest Trees, and for his particularly fine lantern slides, all made from views taken by himself in various parts of the State. Mr. Gill's store of Forestry information was almost illimitable, and he had the valuable asset of being able to impart his knowledge to others in a fluent, pleasing, and instructive way.

Mr. T. P. Bellchambers, that noted and wonderful naturalist, an Honorary Member, passed away in July, and was buried in the Sanctuary at Humbug Scrub, which he, almost unaided, created in the heart of the hills near One Tree Hill. This great nature lover will always be known for his unselfish and untiring efforts to preserve our native wild life, especially the fast disappearing fauna of our State. Perhaps his best work was in connection with the mallee fowl. A pair of these birds he had kept in captivity for more than fourteen years and, as they bred freely, he was able to observe their habits and learn their life history in a way that was incomparable. His observations are recorded in "Nature, our Mother," and also by a fine series of lantern slides taken by himself of his birds. Mr. Bellchambers also secured specimens of kangaroos, wallabies, emus, mallee fowl, ducks, etc., and provided them with a secure and permanent home in natural surroundings. Among the very numerous visitors to the sanctuary were Sir Arthur Conan Doyle, Commonwealth Governors, Generals, State Governors, and many prominent South Australians. It is a pleasure to learn that Mr. Bellchambers' sons will carry on the good work.

Herbert M. Hale, *Chairman*.
Ernest H. Ising, *Hon. Sec.*

SHELL COLLECTORS' COMMITTEE.

This Club met on twenty-two evenings during the year, with an average attendance of fourteen members. Interest in the aims and objects of the Club has been well maintained throughout, resulting in members having now a good working knowledge of the various shell families under review. Twenty-seven distinct families of bivalve mollusca were studied in the order now generally placed by modern conchologists. A majority of the species coming under these families were exhibited, collected by members from various points on our coastline. Without facilities for dredging in deep water, members of the Club have had little chance of discovering new species in beach collecting and thus adding to the excellent tabulated list now in hands of members, but much work still remains in the way of investigating the habits and life history of many of our common species.

The Club exhibited a typical collection of South Australian shells at the Annual Native Wild Flower Show, which was favourably commented on by visitors.

W. J. Kimber, *Chairman.*
F. Trigg, *Hon. Sec.*

MICROSCOPE COMMITTEE.

It is desired to report to the Field Naturalists' Section of the Royal Society of S.A., that the Microscope Committee has successfully completed the second year of its history.

The membership, while not notably augmented, has held to its customary number, and meetings have averaged eight to ten throughout the year.

The year commenced with a dissertation on the technicalities of the Microscope itself, and, later, the policy of the Committee was largely confined to the demonstration of methods of mounting specimens with a view to enabling members to enter more freely into the practical aspects of microscopy. It is hoped that this policy will be further continued, and combined with future demonstrations as to the collection of raw materials suitable for mounting.

Lectures were also given on subjects of interest, as "Micro-photography," etc.

W. A. Harding, *Chairman.*
F. B. Collins, *Hon. Sec.*

FIELD NATURALISTS' SECTION OF THE ROYAL SOCIETY OF SOUTH AUSTRALIA.

Statement of Receipts and Expenditure for the Year ended August 31, 1929.

RECEIPTS.

	£	s.	d.	£	s.	d.
1929—August 31.						
To Balance carried forward, 1/9/29				23	0	4
,, Subscriptions				44	5	0
,, Other Receipts—						
Grant from Royal Society	50	0	0			
Flower Show Profit	33	10	7			
Bank Interest	1	3	7			
Sales of Magazines	0	19	0			
Badges and Sundries	0	4	6			
				85	17	8
				£153	3	0

September 1, 1929. To Balance carried forward, £24 8s. 0d.

EXPENDITURE.

	£	s.	d.	£	s.	d.
1929—August 31.						
By Printing	48	15	6			
,, Advertising	3	0	0			
,, Postage	7	5	0			
,, Hire of Hall, Lantern, etc.	5	3	1			
,, Travelling Expenses	1	8	7			
,, Books, Stationery, etc.	3	19	3			
,, Aquarium Society, Lighting	0	15	0			
,, Sundries	2	17	0			
,, Repayment to Royal Society	44	5	0			
,, Losses on Excursion Account	11	6	7			
				128	15	0
,, Bank Balance, August 31, 1929				24	8	0
				£153	3	0

Audited and found correct—
WALTER D. REED, Chartered Accountant (Aust.) } Hon.
WILLIAM H. BROADBENT, } Auditors.
Adelaide, August 14, 1929.

F. TRIGG, Hon. Treasurer.
Field Naturalists' Section of The Royal Society of S.A.

Excursion Account. — Losses as Under.

	£	s.	d.
1928—			
Sept. 29—Port Willunga	5	0	0
Oct. 10—Myponga: £3 8s. 0d. Profit transferred to Wild Flower Show Account			
Nov. 10—Snow's, Aldgate	1	17	0
Dec. 15—Dredging—Outer Harbour	1	5	6
1929—			
Feb. 16—Dredging Outer Harbour	0	8	1
April 27—Montacute	2	16	0
	£11	6	7

August 12, 1929.

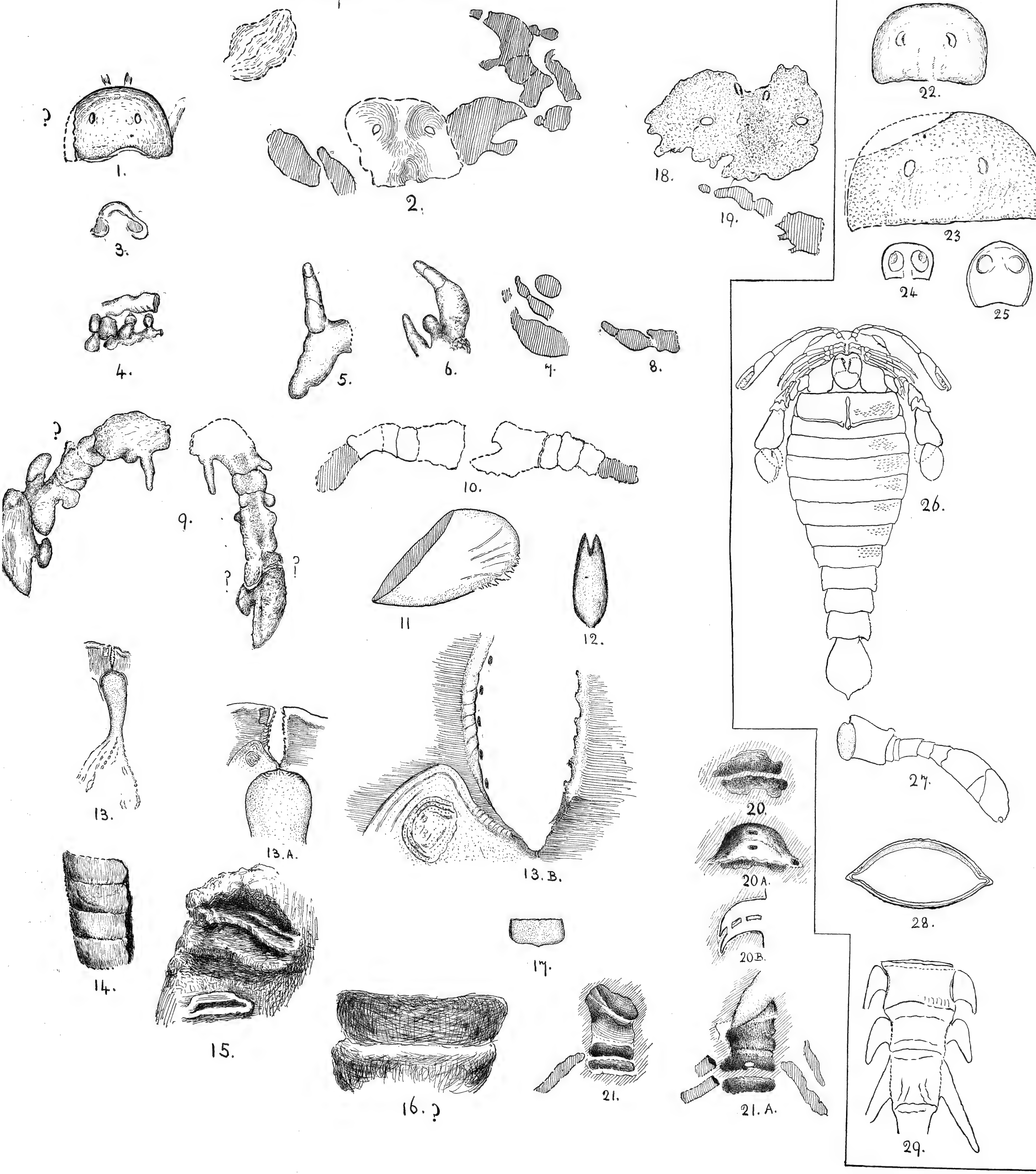
F. TRIGG, Hon. Secretary, F.N.S.

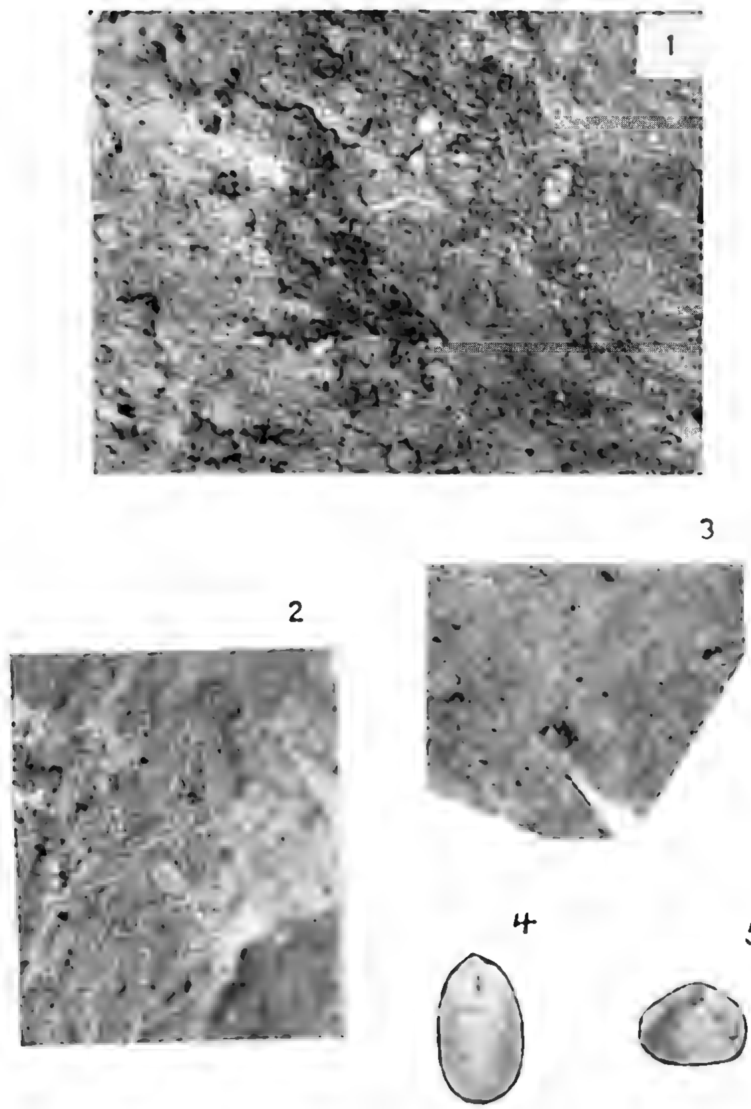
GENERAL INDEX.

[Generic and specific names in italics indicate that the forms described are new to science.]

Remains of Archi-Eurypterids from the Lipalian (?) (late Proterozoic ?) Adelaide Series.
J. W. Edgeworth David del.

SILURIAN and DEVONIAN EURYPTERIDS
for comparison.





Gillingham & Co. Limited, Printers.

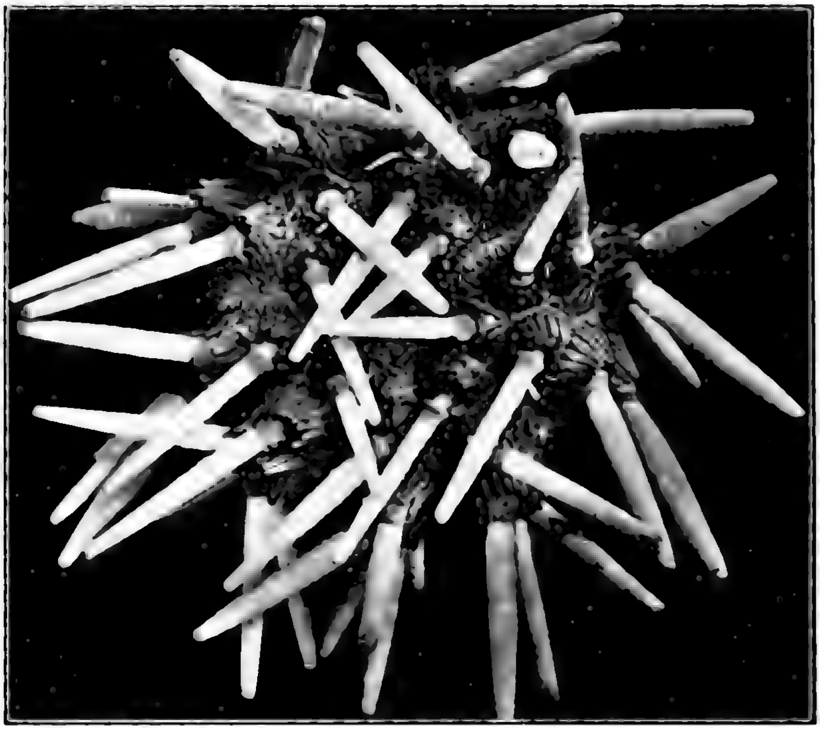


Fig. 2. *Phyllacanthus irregularis* (Mrtsn.). Half natural size.

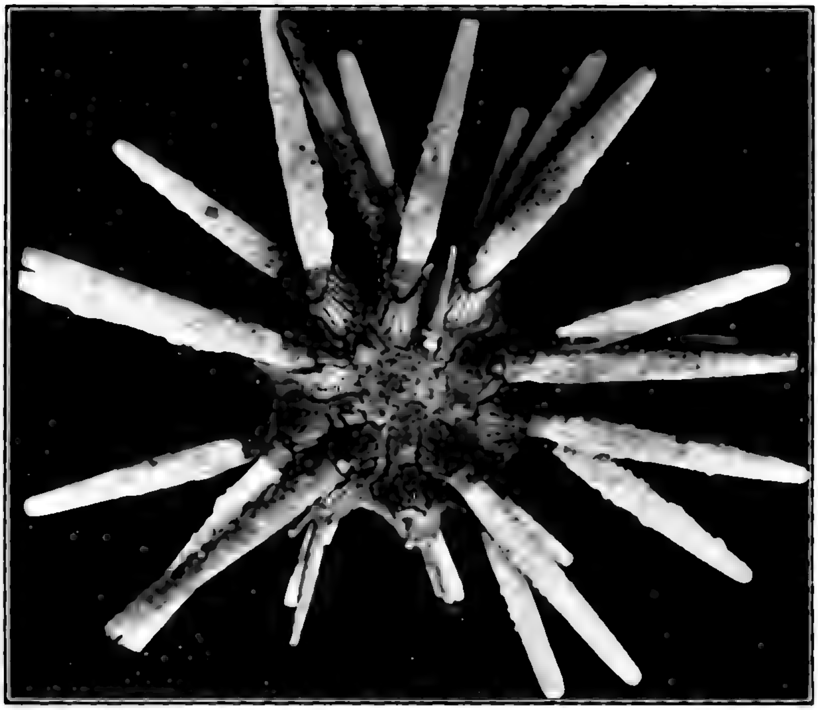


Fig. 1. *Phyllacanthus imperialis* (Lamk.). Half natural size.

Gillingham & Co. Limited, Printers.

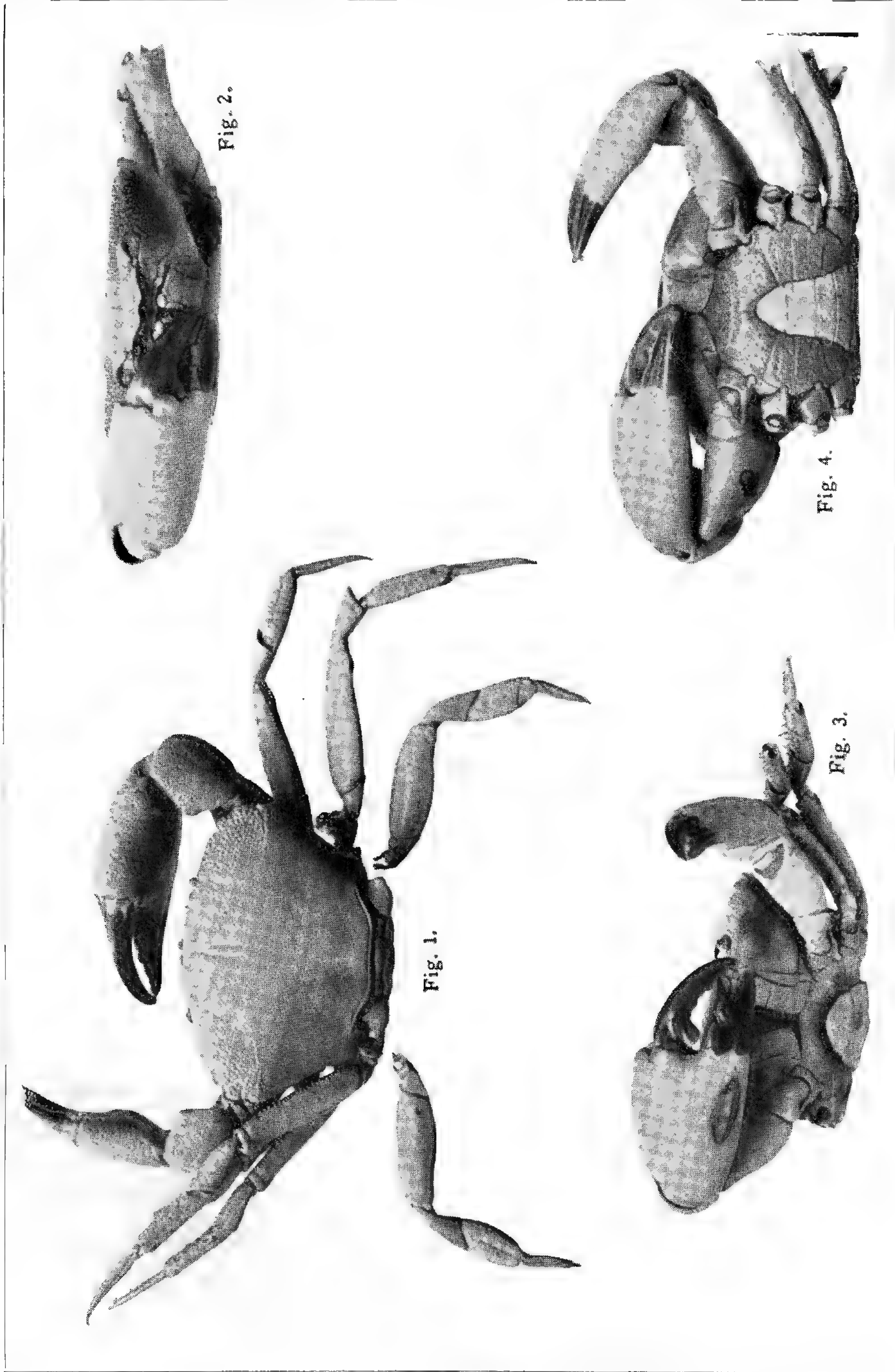


Fig. 1. Fig. 2. Fig. 3. Fig. 4.

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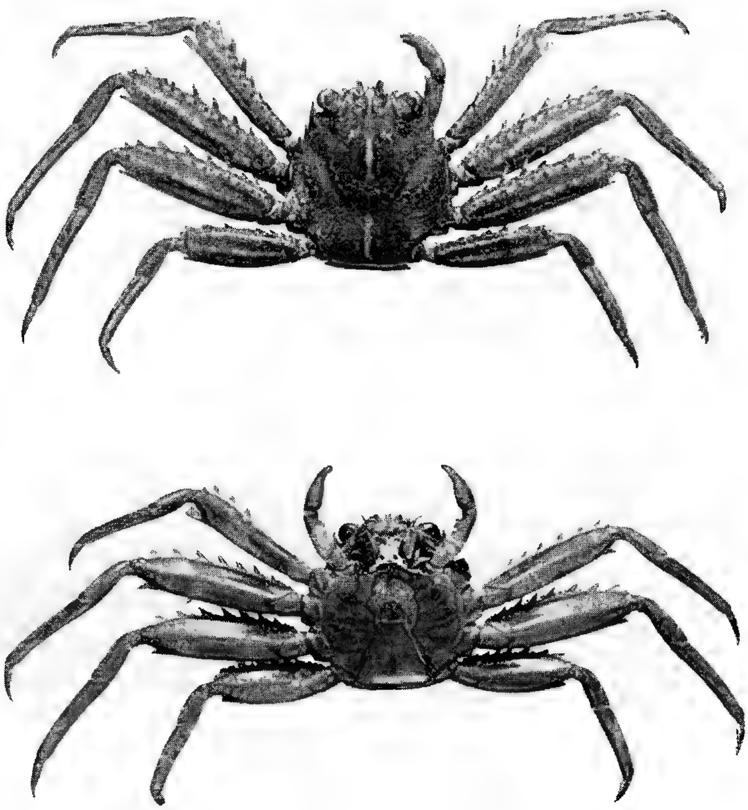

Percnon planissimum, males (x 1½).

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Photo., W. Howchin.

Fig. 1.

The River Murray at Loxton in partial flood.

Photo., W. Howchin.

Fig. 2.

The River Murray at the most southerly portion of the Great Pyap Bend.

Gillingham & Co. Limited, Printers.

Photo., W. Howchin.

Fig. 1.

The River Murray below Loxton, showing the fossiliferous rock on the left bank.

Photo., W. Howchin.

Fig. 2.

Silicified River Murray deposits, one mile above Loxton.

Gillingham & Co. Limited, Printers.

Photo., W. Howchin.

Pumping Station, Loxton, on shelf excavated in river bank.
The light-coloured bed near the top is a fossiliferous fresh-water limestone.

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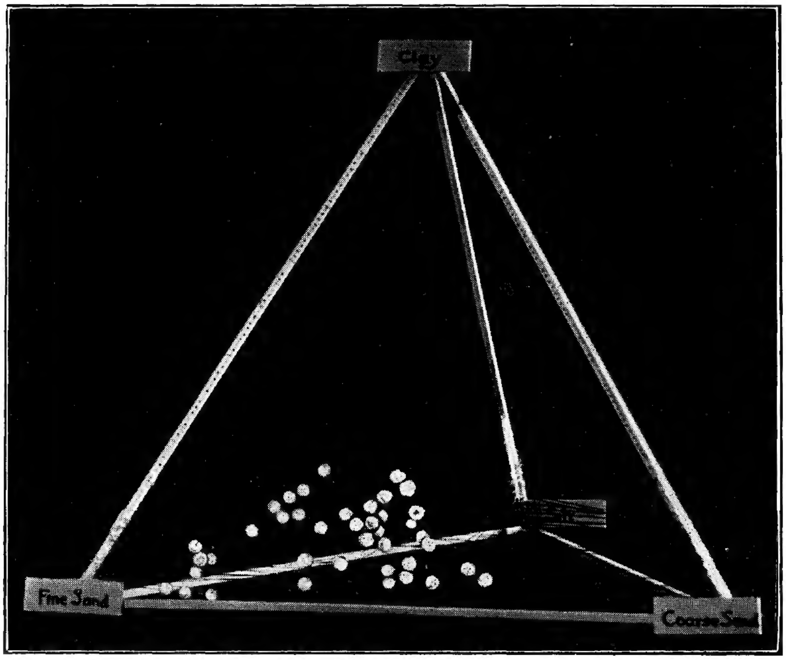

Fig. 1.

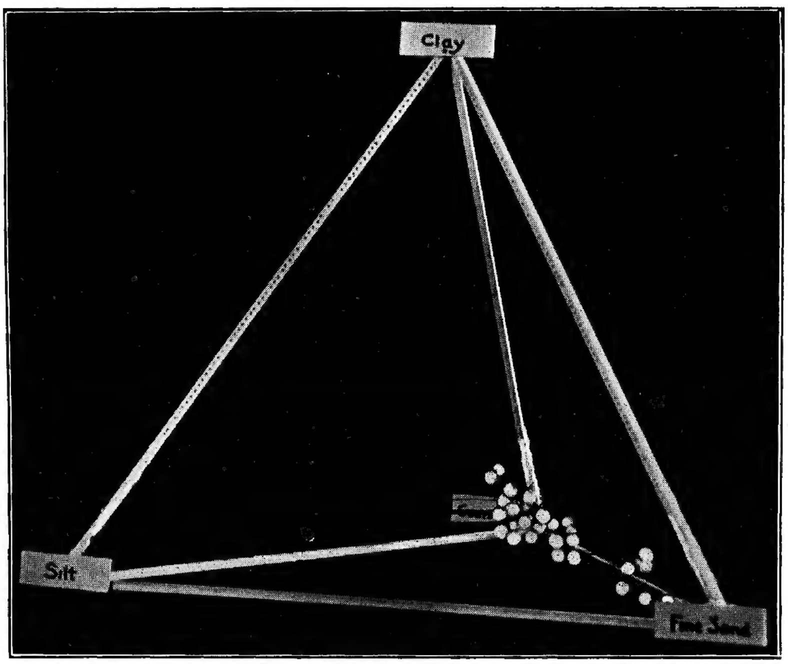

Fig. 2.

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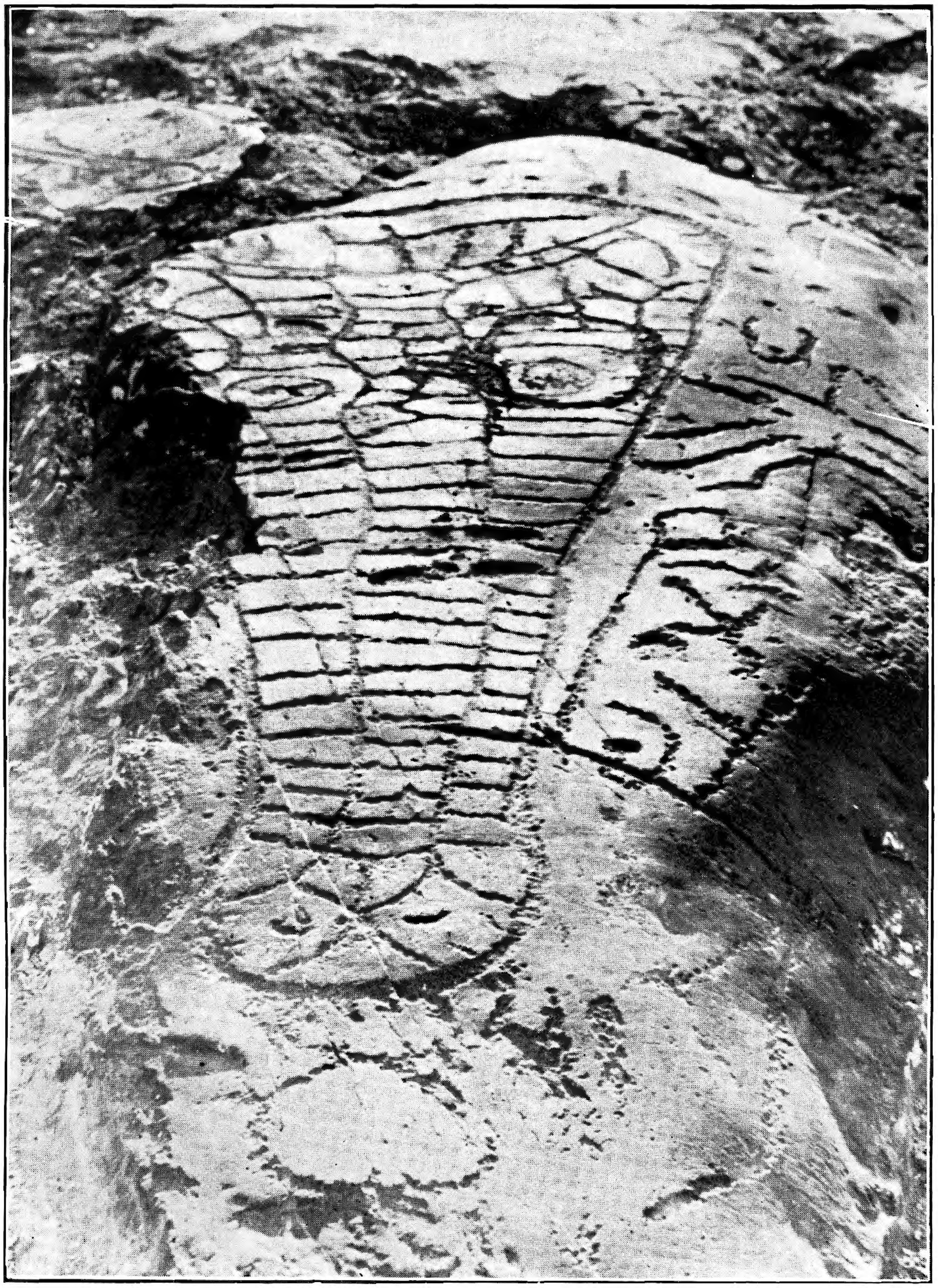

A unique example of Aboriginal Rock Carving at Panaramitee North.

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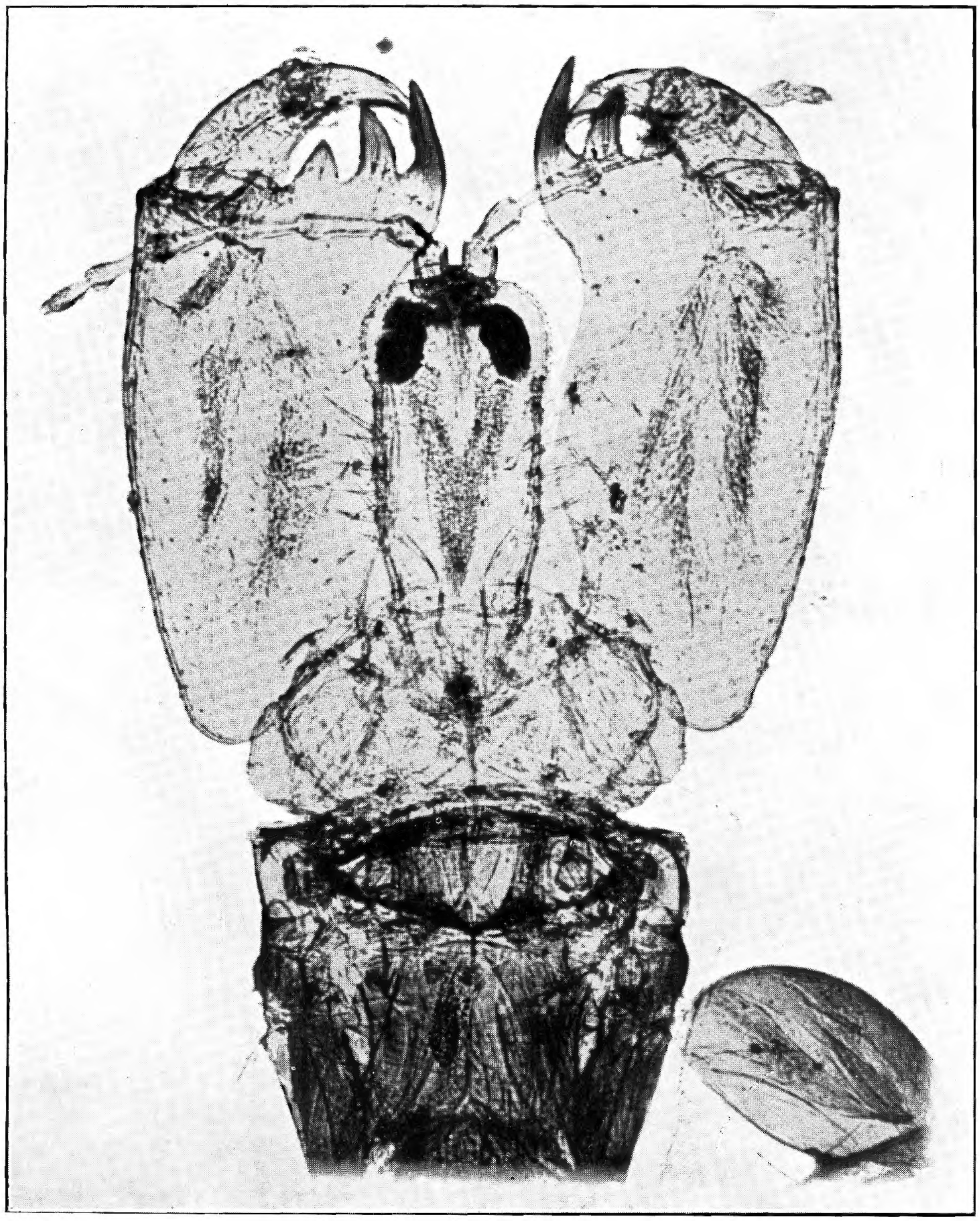

Carcinothrips leai.

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